COMMON CULTIVATED CROPS OF SOUTH INDIA

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BY

V. T. SUBBIAH MUDALIAR

AMUDHA NILAYAM PRIVATE LIMITED
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FOREWORD

This book on the Field Crops of South India written by one who knows the subject well is a welcome addition to the text-books for the degree courses in agriculture of the Universities in South India. The author has brought to bear on the preparation of this book his rich experience for over 30 years in the Madras Agriculture Department both as an executive officer and as a Professor of Agriculture in the Agricultural Colleges at Coimbatore and Bapatla. Though the book is intended primarily for students of agriculture, the author has written it in an easy style and so it can be read with profit by agriculturists and others interested.

The book covers a wide ground and contains a wealth of accurate information regarding all the principal food, fodder and commercial crops of South India. The author must be complimented on his having brought out this useful and timely publication which satisfies a long-felt want at a time when we want that students of agricultural science should be well-trained in the practical aspects of agriculture so that they can advise ryots with confidence. The book will also be useful to teachers teaching agriculture in secondary schools and the extension staff in the National Extension Service and Community Project areas. I have no doubt that the book will be well received on all sides and the author will be given due encouragement.

I trust that the author will in due course turn his attention to the publication of similar books on agriculture and animal husbandry in Tamil and in the other regional languages of South India and thus place his experience and knowledge at the disposal of the agriculturists of this part of the country.

M. BAKTHAVATSALAM
Minister for Agriculture,
Government of Madras.

FORT ST. GEORGE,
7th April 1955.

PREFACE

This book on the common crops under cultivation in South India forms a companion volume to the 'Principles of Agronomy' and the 'Hand book of Animal Husbandry and Dairying' by the same author, which are all primarily intended for the use of students of agriculture and conform to the syllabus prescribed for degree courses in Agriculture, by the Universities in South India. At the same time, it will be of assistance to the general readers interested in the agriculture of the country. Farmers in the several regions have been following certain traditional methods of cultivation with regard to the different crops, which are admirably suited to the soil, climate, local environment and their economic position. It is the author's hope that they will nevertheless get an insight into different methods of cultivation, which are successfully practised equally well in other regions and may reorientate their methods of cultivation, in suitable cases and derive benefit therefrom.

The material for the book has been drawn mainly by the author from his experience of the several regions as an agricultural officer in Madras and Andhra States, and the methods of cultivation followed at the several agricultural research stations in the two States. Notes and jottings made by him for teaching at the Agricultural Colleges at Coimbatore and Bapatla from 1929 onwards, have formed the skeleton of the book. Since these were prepared originally for class use only, references were not systematically maintained and it has not been possible to

list all the books, agricultural departmental publications and agricultural journals consulted from time to time. Only such of the references which can be easily traced have been included in the bibliography. In view of the pressing need for a book of this type covering the cultivation practices in Madras and Andhra States, the author has ventured to release the material for publication, in spite of the said drawback, in the fond hope that the readers would be indulgent and that the authors from whose works materials may have been drawn unconscionably, will forgive this unavoidable lapse. Further, the author feels that the materials collected by him for over 30 years from different regions and the experience gained by him should be made available for the use at large of the general public and the agricultural students, notwithstanding the above defect, in the absence of books on the subject.

The methods of cultivation presented in the book are mainly those which prevail in Madras and Andhra States. Important and interesting methods in vogue in other places and countries have also been touched upon, where necessary, to familiarise the students with other methods as well. Certain crops have been dealt with in some detail on account of their importance and the wide variations seen in the methods of their cultivation. But, even in such cases, it is not claimed that they are complete and full which the reader can look for only in special treatises and monographs. Even these details had to be circumscribed, by limitations of space and the specific requirements of students. Further, a balance had to be maintained between the different sections. Details about the cultivation of minor crops have been kept down to the minimum, with the object of focussing the attention

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of students to the salient features of cultivation and to minimise repetition of details furnished under more important crops.

In a science like agronomy, conditions of soil fertility, climate and crop growth are very varying and its application under field conditions does not give such precise and definite results as physics or chemistry, where the environmental conditions are completely under control. It, is, therefere, inevitable that the personal bias of the author influences the views expressed in some cases.

The author hopes that though the book deals with the cultivation practices in South India, the material included and the explanation of the bases underlying the the various agricultural operations will help the students in other parts of India and be suitable for their use. Almost the same crops are raised throughout India and the main methods of cultivation are the same, though there are slight variations in the method of performing the several operations. There are, no doubt, considerable differences in the rotational and mixed cropping practices in the several regions. Climatic effects and influences are also different. Farmers and students in other parts of the country have to make allowances for these minor variations in the details of cultivation. The introductory section gives an idea of the soil, climate, environment and regional features, which prevail in South India and which govern the several farming practices. The three following sections dealing with the principles of manuring crops, tillage and irrigation have been included, to make the book self-contained for the general reader.

The author's thanks are due to Messrs S. T. Sreenivasan, Assistant to the Paddy Specialist, Coimbatore and

T. Natarajan, Gazetted Assistant to the Director of Agriculture, who assisted the author in editing the manuscript. Thanks are also due to Messrs C. M. John, Director, Coconut Research, Kasargode, S. V. Parthasarathi, Sugarcane specialist, Palur, M. Subbiah Pillai, Superintendant, Central Rice Research Station, Cuttack, M. B. V. Narasinga Rao, Paddy Specialist, Samalkota, P. Krishna Rao, Millet specialist, Coimbatore, and R. Balasubramaniam, Principal, Agricultural College, Coimbatore, who went through sections of the manuscript and offered valuable suggestions for improvement. Special mention has to be made of Messrs T. Gopalan Nayar, Banana Research Officer, Aduthurai, K. Saptharishi, Superintendant, Potato Research Station, Nanjanad and V. Santhanam, Assistant Cotton Specialist, Coimbatore, who rendered help in preparing the sections relating to banana, potato and cotton respectively. Mr. A. H. S. Subramania Sarma, Lecturer in Agriculture, Agricultural College, Coimbatore assisted the author in gathering the statistical data relating to the several crops. Thanks are due to the Paddy, Oil seeds, Millet and Cotton Specialists, Coimbatore and the Sugarcane Specialist, Palur, who furnished the author with data relating to the improved strains of the several crops, released by the Madras Agricultural Department, for cultivation in the Madras and Andhra States included in appendices I, II and III. The various illustrations which enhance the value and usefulness of the book are reproduced with the courtesy of the Director of Agriculture, Madras and of Messrs. Parry and Co. Nellikuppam.

The author is highly indebted and thankful to the Hon'ble Mr. M. Bakthavatsalam, Minister for Agriculture

to the Government of Madras, who has graced the book with the foreword.

Special thanks are due to Messrs Amudha Nilayam Private Ltd., Madras for the neat execution and get-up of the book and for putting up with great patience the several additions and alterations made at the several stages of printing.

AMBASAMUDRAM, 19—11—1955 **V. T. SUBBIAH MUDALIAR**

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COMMON CULTIVATED CROPS OF SOUTH INDIA

CHAPTER I

INTRODUCTORY—SOIL AND CLIMATE

Soil, climate and environment. The choice of crops grown in the different regions of the world and the methods of their cultivation vary widely. Both of them are influenced primarily by the soil, the prevailing climate and environment like the availability of water for supplementary irrigation, suitable labour, market, the resources of individual farmers, their preference etc. The various cultivation practices now prevailing in the different parts of India have been evolved by farmers and peasants as being the most suitable, based on generations of practical experience.

Soil. The study of tropical soils has been rather recent and meagre, when compared with that of the soils in temperate regions. The latter have formed by the weathering of rocks that had undergone a cycle of weathering in the glacial past, or of secondary minerals like the lœss, glacial drift and alluvium. They are not made up completely of weathered material. Weatherable minerals like feldspars, micas and metasilicates are present, as weathering has been over a limited period only. In the tropical and peninsular India, the soils are largely derived from igneous rocks and to a smaller extent from metamorphic rocks and sedimentary rocks. But the weathering has been over a long immeasurable period, without any glacial interference in the past. The velocity and intensity of weathering have also been greater as a result of the influence of climate, and minerals in an unweathered state are not normal soil constituents in South Indian soils.

Land extent and use. The total extent of land in Madras and Andhra States, has been estimated to be 38·5 and 40.5 million acres respectively. They are classified for revenue and administrative purposes, based on land use, as on the next page.

Forests. These include the area covered by tree growths and wild vegetation in hilly and mountainous area and the lands adjoining them. These carry perennial vegetation of a natural type. Several types of trees, bushes, creeping vines, undergrowths including grasses and all kinds of plant life grow side by side, often profusely. There is considerable competition between them and the most hardy and the fittest survive. The forests are useful to the country in various ways

Land classification in Madras and Andhra States, based on the Season and Crop Report of the Madras State for 1952 - '53.

Classification	Madras: Extent in acres	Madras: Per cent of total area	Andhra: Extent in acres	Andhra: Per cent of total area
1. Forests	5,995,360	15.6	7,854,860	15.8
2. Barren and uncultur-able waste	2,887,303	7.5	5,953,823	14.7
3. Land put to non-agri-cultural use	3,487,931	9.1	2,329,734	5.7
4. Culturable waste	2,857,099	7.4	3,627,002	8.9
5. Permanent pastures and grazing areas	1,121,453	2.9	721,067	1.8
6. Land under miscella-neous crops, excluded from net area sown	1,261,394	3.3	552,800	1.4
7. Current fallows	3,293,515	8.6	2,753,926	6.8
8. Other fallows	2,237,456	5.8	1,631,086	4.0
9. Net area sown	15,310,116	39.8	15,154,147	37.3
10. Area sown more than once	2,500,802	6.5	2,171,880	5.4
11. Total cropped area	17,810,918	46.3	17,334,027	42.7
12. Total extent	38,451,627		40,578,535	

and are an asset to the country's wealth. They regulate rainfall and the supply of water to the rivers, which tra-verse South India from west to east, and thus facilitate the irrigation of extensive rice lands. They produce

timber, fuel, minor produce, medicinal herbs etc. Lastly, they provide some useful grazing for the cattle kept in in the villages nearby. Their productivity is attempted to be improved in various ways. Unwanted vegetation is kept in check to an extent, the growth of desirable plants and trees is encouraged and suitable areas are planted with useful crops like tea, coffee, rubber, cinchona, teak etc. The forests occupy an area of 6 and 8 million acres respectively in Madras and Andhra States. It is not considered safe to encroach on this area and divert any part of it for the production of field crops.

Barren and unculturable waste. These are represented by mountains, deserts etc., and cannot be cultivated.

Land put to non-agricultural use. Land occupied by villages, towns, roads, railways, rivers, tanks, channels etc. are included in this class.

Culturable wastes. These are infertile lands, which have either not been taken up for cultivation or abandoned after a few years of cultivation, when it becomes uneconomical. These are sub-marginal lands, which cannot be easily brought under cultivation or cultivated in an economical manner. Possibly the pressure of population may force the future generations to tap these lands also for cultivation, by investing sufficient capital and labour in a suitable manner. It is not possible to say how much of these lands will be brought under cultivation, by devising appropriate methods in the future.

Other classes of land. 'Permanent pastures and other grazing lands' represent perennial grass land, communal lands reserved for grazing and other grazing grounds. 'Current fallows' represent lands, which are under cultivation, but which are not sown during the

year, under reference. Their extent varies from year to year. 'Other fallows' represent those, which have been fallow for a period of one to five years, but not for longer periods. 'Net area sown' represents the actual extent of land sown during the year. Some of them are cropped more than once during the year and their area is added to the net area sown, to arrive at the total area sown during the year. The area cultivated varies with the seasonal conditions prevailing in any year and the extent of cultivation in a year does not give such a correct picture as the average of some years. These averages are worked out for the 5 years preceding the year of reference in the Season and Crop Reports and called '**normal**', with regard to the extent of cultivation, output per acre and the total production of crops. The normal extent of cultivation of the different crops furnished in the text is the average of 5 years ending 1951-'52 and is based on the Season and Crop Report of the Madras State for the year 1952-'53.

Wet, dry and garden lands. Agricultural land is classified into (1) wet, (2) dry and (3) garden lands in South India. The crops raised on these lands are called "wet', 'dry' and 'garden' crops and the systems of cultivation are called 'wet', 'dry' and 'garden' cultivation respectively. This nomenclature will be adhered to in the following pages. 'Wet lands' are under gravitational flow irrigation from river and tank irrigation systems mostly. These are stagnated with water and devoted to the cultivation of rice under swamp conditions, ordinarily. Crops like banana, sugarcane and turmeric are also grown in wet lands, in high level areas which have facilities for suitable drainage. Water is not stagnated in the field for these crops as for rice, and irrigation is provided only as and when necessary. Certain lands are cropped mainly under

rain fed conditions. They are not irrigated and they are called 'dry' lands. Where water table is high, underground wells are dug and water is lifted commonly with bullocks and used for irrigating crops. Since water has to be raised at great cost, lift irrigation is provided for supplementing the natural rainfall, only to the extent necessary and not liberally as for wet lands. They are irrigated dry lands, called 'garden lands'.

Soil types. Based on similarities of characteristics, the soils in South India can be divided into 4 main types, namely (1) alluvial soils, (2) red soils, (3) black soils and (4) laterite soils.

1. *Alluvial soils.* These are formed by the deposition of silt from the rivers along their course, both on their flanks and their estuaries. Large alluvial deltas have been formed in this manner by the rivers Godavari, Krishna and Cauveri. Small areas have also been formed in South Arcot and Tirunelveli districts. It is estimated that these alluvia cover an area of one million acres in Madras and Andhra States. The depth of the alluvia is variable and the profiles show layers of sand, silt and fine clay. They are not related to the rocks underlying them. They are generally fertile and the fertility is linked with the proportion of the finer fractions of the soil. The alluvia partake the nature of the soil drained by the respective rivers. Rivers Godavari and Krishna drain black soil areas and the alluvia formed are also black, clayey and fertile. The Cauveri River drains red soils of a mixed type and the soil formed is of a lighter colour, loamy and not so fertile as the Godavari and Krishna deltas. The alluvial soils are under wet cultivation, with rice as the main crop.

FIG. 1. Lifting water with mhote from wells.
—*Courtsey: Director of Agriculture, Madras.*

2. *Red soils.* The red soils are very predominant, occupying nearly two-thirds of the cultivated area or about 20 million acres in Madras and Andhra States. They are derived from granites, gneisses and allied rocks of the micaceous type, which are poor in lime and magnesia, but include potassic feldspars predominantly and are resistant to weathering. The soils are red in colour, of varying shades, due to the presence of iron oxides in a free state, not forming an integral part of the silicate complex of the soil. They are light soils with the texture varying from gravelly and sandy type to loams. They are of the kaolinitic type, though in the mixed types of red soils, there may be present varying proportions of montmorillonite, depending upon the composition of the parent material. They are generally shallow and low in soluble salts. The depth of the soil ranges from 1½ to 3 feet, though in certain places 6 to 8 feet depth of soil can also be met with. There are deposits of 'kankar', or lime nodules, of varying depth in the lower layers in most cases. The soils are poor and their base exchange capacity is low, being about 10 milli-equivalents. The pH of the soil is 7 to 7.5. Physically, they are excellent and capable of growing all crops under irrigation.

Red soils absorb water easily, permit easy movement of water and are very permeable. A large part of the rain is passed on to the lower layers of the soil and the underground water table. The soluble salt content of the soil and of the underground water is low. High water table and low salt content of the water facilitate economic cultivation in these soils with lift irrigation from wells sunk underground.

Red soils are generally shallow, poor in organic matter content and plant nutrients. They respond, however, very well to manuring and irrigation, on account of their satisfactory physical condition. They are referred to as 'hungry and thirsty soils' in common parlance, as they need plant food and water rather liberally. They are the opposites of black soils in almost all physical and chemical properties.

Early and late soils. Since the red soils are highly permeable and water moves through them easily, they are rendered moist and fit for sowing even by light rains. They part with their moisture readily and a large part of it becomes available for the use of crops. They have a low water holding capacity and crops suffer unless rains are had at frequent intervals in a timely manner during the period of growth. Light rains are had at frequent intervals with the onset of the south-west (S. W.) monsoon in June and red soils are then taken up for sowing, but the moisture status of the other soils do not favour sowings being done at the time. Since red soils permit sowings being done earlier than other soils, they are called 'early soils'. The black soils are not much benefited by the light showers received early in the season. Their permeability is low and the rain water is held on the surface and is evaporated. It does not help to add to the stock of moisture in the soil and it does not facilitate sowings being taken up just then. When later in the season, the regular north-east (N. E.) monsoon sets in, the black soils are moistened sufficiently for taking up sowings. The heavy black soils are, therefore, called 'late soils'. For example, red soils are sown in June-July and black soils in August-September, in the Ceded districts. When once the black soil is moistened sufficiently,

the moisture is retained by the upper layers, without being passed down rapidly to the lower layers and becomes useful for the growth of crops. The red soils, on the other hand, pass down the water rapidly to the lower layers and their capacity to hold moisture for the use of crops is limited.

The light soils in the temperate regions are also called 'early soils', as they get fit for sowing earlier than other soils. The moisture, however, is not the factor that determines the earliness. The temperature of the soil that had been lowered during the preceding winter is raised early in spring due to its open texture and the free movement of the warm spring air inside the soil. The soil organisms then get active, and oxidation of the organic matter in the soil and nitrification commence. Early sowings are thus rendered possible. Aeration and warming up of heavy soils are hampered by the small size of the individual pores, and the soils warm up slowly only and get fit for sowing rather later, and they are hence called 'late soils'.

3. *Black soils.* These are also called the 'black cotton soils' and form an important group of soils. These occupy about a third of the cultivated area in Madras and Andhra states, in about 10 million acres. Guntur, Krishna, and the Ceded districts have extensive black soil areas, while Tiruchirapalli, Madurai, Ramanathapuram, Tirunelveli, Coimbatore and Salem districts have small areas. These are sedentary soils, derived from granite and gneiss mostly and in certain cases from lime stone and shale formations, as in parts of Kurnool and Cuddapah. Similar soils have been formed from basalt in Bombay, Madhya Pradesh and Hyderabad States. In

South India, the parent rocks are mostly of the same group as those which have given rise to red soils, but with different mineralogical and chemical composition. The parent rocks which underlie black soils are of the hornblendic type, rich in lime and magnesia and the associated feldspar is of the lime-soda type predominantly. This type weathers easily and the depth of the soil formed is often considerable. There are shallow soils of about 4 feet depth and deep soils of 6 to 10 feet and more. The soil layer is practically uniform throughout the profile. Calcium carbonate nodules or 'kankar' are formed, either in a dispersed state or in layers of varying thickness, at 3 to 6 feet below the surface. Varying quantities of gypsum are deposited in the lower layers of the soils in the Tungabadra project area.

The black soils are clayey in nature and have characteristic clay properties. They absorb water very slowly and the movement of water in the soil is very slow, as the soils are fine and the individual pores are small in size. They have a high water holding capacity and rain water held in the soil becomes useful for crops. The water table is rather low. The soluble salts of weathering load the underground water, which is consequently brackish. Since the water table is low and the water is brackish, irrigation from underground wells is not commonly done. The water is not suitable for irrigation, in general. Lift irrigation is also not economical, except for commercial crops like tobacco and chilli, which stand brackish water better than other crops.

The black soils are generally well supplied with plant food ingredients and their base exchange capacity is rather high. Good crops are raised where conditions of

rainfall are favourable, as in the Guntur-Krishna region. Where rains are precarious, the crops are poor, but when once the soil gets moistened enough for sowings being undertaken, the moisture held in the soil may normally take the crops to maturity. For example, sorghum is sown in the black soils of the Bellary region in October, practically after the cessation of the monsoon rains. There are no rains after sowing in certain years and yet, some yield is obtained, though low. When some rains are received in November and December, crops make good growth and give heavy yields. Under the same conditions, red soils will not be able to carry crops to maturity.

The black soils shrink in volume on drying and expand on wetting, consequent on the clayey nature of the soil. During drying, large cracks develop in all directions on the surface and these may extend vertically down to the kankar layers formed at a depth of 3 to 4 feet and to the entire depth of the soil, where the kankar is dispersed and not massed in layers. The cracks facilitate the downward movement of water in the soil when the monsoon breaks out. The soil swells on moistening, and cracks formed during summer are then obliterated, but it is probable that the surfaces of the cracks may not bind firmly and completely, and space may yet be available for the slow downward movement of water.

The black soil is sticky and tenacious when moist, and granular and crumbly when dry. The structure of the soil is satisfactory. The granularity is presumably associated with the satisfactory lime status. The organic matter content is low in common with the other South Indian soils and it cannot be responsible for the granularity of this soil.

4. Laterite soils. This is the only member of the world group of zonal soils found in South India. Laterite soils have been formed in about 2 million acres along the Malabar coast and South Kanara districts fringing the Arabian sea, where the average annual rainfall ranges from 100 to 150 inches. The soil is red in colour and of varying depth, ranging from 6 to 10 feet, with a layer of kaolin below. The kaolin is white or grey, 5 to 10 feet deep and rests on parent granite and gneiss rock formations. The soils are heavy and well drained, with sesquioxides predominating and leached of bases and silica to a large extent. They have a low base exchange capacity, a low sesquioxide ratio of less than 1.33 and a pH of 6 to 6.5. They are poor in all plant nutrients, particularly in calcium and potassium. Though the phosphorus content is not low, it is in combination with iron and aluminium and is not readily available for the use of plants. The natural vegetation in forest soils is of a rich luxuriant type and variety, and does not disclose the poverty of the soils. The plant nutrients are practically in a state of circulation and the available nutrients pass from the soil to the plants and get back to the soil through the leaf fall. When the forest growth is cleared and land is brought under cultivation, a few good crops can be harvested with the nutrients readily available in the soil and thereafter the inherent low fertility of the soil asserts itself. Rice is the main crop grown here under purely rain fed conditions. Banana, tapioca, ginger and minor cereals are the other crops. Pepper and coconut are perennial crops, which come up well and can be maintained without much attention.

Climate. South India is in the tropical zone. Madras is between 8° and 14° North Latitude and 74° and 79°

East Longitude and Andhra is between 14° and 19° North Latitude and 77° and 85° East Longitude. The prevailing mean temperature is naturally high. The maximum temperature in summer ranges from 95° to 105°F. and minimum temperature in December ranges from 55° to 65°F. The Nilgiris in Madras has a mild temperate climate, on account of its altitude.

Rainfall in South India. The distribution of rains in South India is of a monsoon type, with particular seasons of rainfall and intervening dry periods. The cropping and cultivation have been adjusted to these seasonal conditions. The hot weather period is from 1st February to 6th June, the S. W. monsoon from 7th June to 26th September and the N. E. monsoon from 27th September to 31st January. The average monthly and seasonal rainfall in inches over a series of years ending with the year 1940 for the several districts in Madras and Andhra States, based on the Season and Crop Report of the Madras State for the year 1950-'51, are as on page 14.

I. The hot weather period. The rainfall during the hot weather period is little, with the average rainfall in most districts ranging form 3 to 6 inches. February and March are practically rainless and this facilitates the harvest of the previous season crops of both dry and wet lands. When there are any rains, they benefit the cold weather crops like gingelly, *ragi* and pulses, but they interfere with the harvest of rice, sugarcane etc., and do more harm than good. Cotton plants shed their bolls, the quality of the maturing tobacco is adversely affected by the gums and resins on the surface being washed off and the ripe chilli fruits cannot be dried properly. The weather during this period is cool and dry, usually, with

Average monthly and seasonal rainfall of the districts in inches.

Name of district.	February	March	April	May	June	July	August	September	October	November	December	January	Hot Weather Period	South-West Monsoon	North-East Monsoon	Total anuual rainfall
Srikakulam	0·7	0.6	1.1	2·7	5·1	6.4	7.5	7.9	2·7	7·2	0·6	0·2	5·1	26·0	10·6	42·6
Visakhapatnam	0·7	0.6	1.0	2.6	4.5	4·8	5.6	7.3	7.8	3.4	0·6	0·3	4·9	22·2	11·9	39·0
East Godavari agency	0.5	0.7	1.6	2.4	6.3	11.9	10.1	8.9	5.3	1·8	0.2	0·2	5·2	37·0	7·5	49·7
East Godavari plains	0.4	0.4	0.7	1.9	5.0	6.9	6.2	6.9	8.5	4·3	0.4	0·2	3·4	25·0	13·4	41·8
West Godavari	0.4	0.4	0.7	1.8	5.1	7.8	7.1	7.0	6.8	3·2	0.2	0·2	3·3	27·0	10·4	40·7
Krishna	0.4	0.4	0.7	1.5	4.4	7.0	6.5	6.2	6.1	3·3	0.3	0·2	3·0	24·1	9·9	37·0
Guntur	0.4	0.3	0.6	1.6	3.3	4.6	4.9	5.7	6.2	4·0	0.5	0.3	2·9	18·5	11·0	32·4
Kurnool	0.2	0.2	0.7	1.4	2.6	3.8	4.0	5.3	3.8	1·8	0.3	0·1	2·5	15·7	6·0	24·2
Anantapur	0.2	0.2	0·8	2.0	2.1	2.2	3.3	5.3	4.0	1·9	0·3	0·1	3·2	12·9	6·3	22·4
Cuddapah	0.1	0.2	0 7	1.6	2.4	3.2	4.0	5.0	5.0	3·7	0.9	0·3	2·6	14·6	9·9	27·1
Nellore	0.3	0.3	0·5	1.4	1.6	2.6	2.9	4.1	8.9	9·3	2·6	1·0	2·5	11·2	21·8	35·5
Chittoor	0.4	0.4	1.0	2.4	2.4	3.0	4.1	5.4	6.1	6·0	1.8	0·7	4·2	14·9	14·6	33·7
Chingleput	0.5	0.4	0.6	1.4	2.0	3.5	5.0	5.2	10.2	12·1	4·6	1·3	2·9	15·7	28·2	46·8
South Arcot	0.6	0.5	1·1	1.9	1.8	2.9	5.4	5.7	8.9	10·9	5·4	1·7	4·1	15·8	26·9	46·8
North Arcot	0.3	0.4	0.9	2.6	2.4	3.4	5.3	6.5	6.5	6·4	2·3	0·9	4·2	17·6	16·1	37·9
Salem	0.3	0.5	1.7	4.1	2.2	2.5	4.3	5.3	6.1	4.0	1·2	0·4	6·6	14·3	11·7	32·6
Coimbatore	0.4	0.7	2.1	3.4	1.4	1.5	2.1	2.9	6.6	4·4	1·4	0·5	6·6	7·9	12·9	27·4
Tiruchirapalli	0.4	0.5	1.7	3.3	1.4	1.6	3.7	4.9	7.1	5.9	2·7	1·0	5·9	11·6	14·7	34·2
Tanjore	0.7	0.7	1.5	2.0	1.4	1.9	3.8	4.2	8.2	11·6	6·9	2.2	4·9	11·3	28·9	45·1
Madurai	0.6	0.8	2 4	2.9	1.3	1.4	2.7	3.5	7.3	6·1	2·3	1·0	6·7	8·9	16·7	32·3
Ramanathapuram	0·8	0.9	2.1	2.0	0.9	1.2	2.4	2.8	7.1	7·1	3·5	1·5	5·8	7·3	19.2	32·3
Tirunelveli	1.2	1.5	2.1	1.4	0.8	0.7	0.8	1.1	6.7	7·9	4·4	1·8	6·2	3·4	20·8	30·4
Malabar	0.3	0.8	3.4	8.1	30.4	33.9	18.6	8.3	10.6	5·4	1·0	0·3	12·6	91·2	17·3	121.1
South Kanara	0.1	0.2	1.6	5.9	39.8	47.5	28.7	12.4	9.2	3·2	0·6	0·2	7·8	128·4	13·2	149·4
Nilgiris	1.0	1.4	3.6	6.0	9.4	14.5	10.6	7.1	10.0	6·9	2·6	1·3	12·0	41·6	20·8	74·4

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dew in the night. There are steady north-east winds, which gradually change their direction and become easterly winds and latter south-easterly winds, which go by the name of *pyru-galli* in Andhra Desa and *uppam kathu* in Tamil Nad. This wind invigorates the standing crops, particularly the cotton standing in dry lands.

April and May are the hottest months of the year. Some rains may be had during this period, which go by the name of 'summer showers' or 'mango showers'. They are of the nature of thunder storms, often confined to the afternoons, with thunder and lightning. Gingelly and early sorghums are sown with the rains. The standing garden land crops are benefited. The hot weather rains are confined to April and May in Tirunelveli and Ramanathapuram districts, which may sometimes be pre-monsoon showers. Advantage is taken of the rains and the land is prepared by ploughing with the moisture in the soil, for the next season's crops. The rains are uncertain in quantity and time, and cannot otherwise be utilised. The first few inches of soil are moistened by the rains and the prevailing high temperature evaporates this moisture quickly. It is not stored in the soil, the stock of moisture in the lower layers of soil is not supplemented and it does not, therefore, become useful to the next crop.

2. *The south-west monsoon season.* This extends from 7th June to 26th September and is the grand period of general rainfall in South India. The S. W. monsoon rains range from 11 to 25 inches in most districts and 90 to 130 inches in the West Coast districts; Coimbatore and the southern-most districts of Madurai, Ramanathapuram and Tirunelveli alone receive a low rainfall of 3 to 8 inches.

The S. W. monsoon establishes along the West Coast by about the first week of June. Rains are received in the other districts in July, June being almost dry. The bulk of the sowings in the light red soils is done during this period. If the rains are delayed, sowings become unseasonal and short duration varieties or less valuable crops have to be sown. The delay in rains does not, however, affect the heavy black soils, which are sown late in September ordinarily or October during the N. E. monsoon season. The S. W. winds give place to N. E. winds by about the middle of September or a little later.

The S. W. monsoon rains received in the Western Ghats feed the rivers Godavari, Krishna, Cauveri and Tambaraparani, which traverse the peninsula west to east and provide irrigation for rice crops in wet lands. These rains are useful for garden lands also, and irrigation for standing crops is considerably reduced. The water supply in wells improves.

It may be said that the prosperity of South India is largely dependent on the seasonableness and adequacy of the rains in the S. W. monsoon season. The majority of the dry lands and wet lands depends directly on these rains. The garden lands are also benefited to some extent.

3. *The north-east monsoon season.* This monsoon period extends from 27th September to 31st January. Heavy rains are received along the Coromandel Coast and continue till about December. The N. E. monsoon wind commences by about the middle of September and both the S. W. and the N. E. winds blow irregularly during the second fortnight, each blowing for a part of the day. The S. W. winds cease completely by the end of September and

N. E. winds get established firmly. The south Tamil Nad least influenced by the S. W. monsoon is most benefited by the N. E. monsoon.

The N. E. monsoon rains are helpful in filling the rain fed tanks, on which rice cultivation depends and they are of special importance in tank fed regions like Chingleput, Visakhapatnam, Ramanathapuram and Tirunelveli Districts. The sowing of the rain fed heavy black soils is done with these rains.

The N. E. monsoon rains are heavy and destructive in certain years. Cyclonic stroms develop in the Bay of Bengal and strike the East Coast. Considerable damage is sometimes brought about by tidal sea waves flowing over cultivated lands along the coast, inundating them and making them unproductive. Heavy rains tend to lodge the rice crops in flower and reduce the yield eventually. Sugarcane fields are water logged and have to be propped up to prevent the lodging of the crop in the Northern Circars. Tobacco nurseries and fields suffer. The harvest of early rice crops is also affected adversely by late heavy rains. The rains benefit the southern districts in Tamil Nad effectively.

The climatic zones. Based on rainfall and cropping, the Madras and Andhra States can be divided into 7 distinct climatic zones. They have their own patterns of climate and cropping, which are different from those of others. The soil, climate and cropping are more or less of the same type within each zone and the classification made appears to be justified. Their climatic peculiarities and features are given below :

1. Northern Circars. This zone comprises the districts of Srikakulam, Visakhapatnam, Godavari (west

and east), Krishna and Guntur. The Annual rainfall ranges from 30 to 40 inches, going up to 50 inches in certain places, distributed over 65 to 70 days, mostly in the S. W. monsoon period. The spread of the average maximum temperature is 86° to 99° F. and that of the minimum temperature 64° to 79° F. The summer temperature goes up to 110° to 112° F. and may be more in isolated places. The region is benefited by the Godavari and Krishna irrigation systems. The rice lands are rich black alluvial soils. The rain fed upland areas are red soils down to Godavari in the south and black cotton soils in Krishna and Guntur. The soils are rich, the rainfall is abundant and these are rich agricultural regions, benefited by a bountiful nature.

2. *The Deccan.* The Deccan, otherwise called the Ceded Districts, comprises Bellary (now part of Mysore) Anantapur, Cuddapah and Kurnool districts. These are arid regions in South India and have an annual rainfall of 20 to 30 inches, distributed over 50 to 60 days. The spread of the average maximum temperature is 85° to 104° F. and that of the minimum temperature 62° to 80° F. The maximum temperature may go up to 110° F. in summer and the minimum temperature may touch 55° F. in December-January. Both black and red soils are met with. Rainfall limits the productivity of land and one good year is often followed by 2 or 3 precarious years. Living conditions are trying for both men and cattle, and the density of population is consequently low.

3. *The Carnatic.* This comprises Nellore, Chingleput and South Arcot districts, which have a well distributed annual rainfall of 35 to 40 inches. The mean temperature ranges from 75° to 85° F., with a bare

difference of 15°F., between the maximum and the minimum. Red soils and alluvial flats predominate this region. Tank and well irrigation are common features of cultivation.

4. *Central districts.* These comprise Chittoor, North Arcot, Salem and Coimbatore districts. The first two are like the Carnatic in climate and the last two are arid regions, which receive 20 to 30 inches of rainfall annually on the average. The spread of the average maximum temperature is 87° to 99° F., and that of the minimum temperature is 64° to 76°F. Red soils are predominant, with patches of black soils here and there. The crop is uncertain in years of low rainfall, but this is not so common or so widespread as in the Deccan.

5. *The Southern districts.* These include Tanjore, Tiruchirapalli, Madurai, Ramanathapuram and Tirunelveli districts and this is the region of the N. E. monsoon rainfall. Tanjore and Tiruchirapalli get the additional benefit of the S. W. monsoon also and are therefore better placed agriculturally. Tanjore is the granary of the Madras State, with the largest rice acreage. The rainfall is uncertain in portions of Ramanathapuram, where farmers lead a life of marginal existence. The average maximum temperature spreads over 83° to 96° F. and minimum temperature over 64° to 74° F. The average annual rainfall is 30 to 35 inches, except in Tanjore, which gets 45 inches.

6. *The Nilgiris.* This has an elevation of 3,000 to 8,000 feet above mean sea level and has a cool temperate climate. The average maximum temperature ranges from 60° to 75° F. and minimum from 45° to 55° F. The annual rainfall of 75 inches is well distributed over

150 days. Wheat, potato and exotic vegetables are important crops. *Ragi*, *samai* and *korali* are also grown. Tea and coffee are important plantation crops.

7. *The West Coast.* This comprises Malabar and South Kanara districts, which are coastal strips skirting the Arabian sea. They get the full force of the S. W. monsoon and the average annual rainfall is 121 inches in Malabar and 149 inches in South Kanara, distributed over 135 to 140 days. The average maximum temperature ranges from 83° to 98° F., and the minimum temperature from 68° to 82° F. The climate is warm and moist. The soils are lateritic, leached and poor in plant food ingredients. As the rainfall is high, rice, coconut and arecanut are grown as rain fed crops. Coffee, tea and rubber plantations are raised at suitable elevations.

CHAPTER II

PRINCIPLES OF MANURING CROPS

Manures. Crops obtain the plant food they require for their growth from the soil and this is a loss to the soil. If the loss is not made up by the addition of substances containing plant food, the capacity of the soil to produce good crops is reduced gradually. The substances, which are added to the soil for supplying plant food, are called 'manures' and 'fertilizers'. The terms manure is specifically used for denoting organic manures like cattle manure, green manure, composts etc., which are general manures and supply all ingredients of plant food. It is also used in a general way to denote inorganic substances like sodium nitrate, ammonium phosphate, potassium sulphate etc., which are extremely rich in one or two ingredients of plant food only. These are specifically called 'fertilizers'.

The soil is a large storehouse, which contains large quantities of plant food, mostly in insoluble forms. These are acted on by weathering agencies and the plant food in the soil is rendered soluble gradually and made available for absorption by plants. The rate of release of such available plant food indicates the productive capacity of land; rich soils release more and poor soils less. The plant food thus released is not sufficient for the production of heavy crops, nor are the various plant food ingredients in the proportion required by plants. The growth of crops is limited by the ingredients that are in short supply and hence, there arises the need for applying

manures and fertilizers to land. Nitrogen, phosphorus and potassium are the 3 major ingredients which are in short supply in the soil ordinarily all over the world. The nitrogen content in soils, manures and crops is denoted by the quantity of elemental nitrogen (N), while phosphorus and potassium are denoted by the content of their oxides, P_2O_5 and K_2O, called phosphoric acid or phosphates and potash respectively.

How nutrients are held in the soil. Nitrogen is present in soils, as a constituent of organic matter alone. It is in insoluble forms and is not useful as such to plants. It is converted gradually to ammonia, nitrites and finally nitrates, as a result of bacterial activity. Nitrates are soluble and plants absorb nitrogen mostly in the form of nitrates, though small amounts of amino acids and ammonia may also be absorbed. The nitrates are very mobile and are liable to be leached from the soil during wet weather, when there are no crops on the land for utilising them.

Atmospheric nitrogen is fixed by certain types of bacteria living in the soil like the *Azotobacter* and the legume bacilli and their dead remains get converted to humus eventually. Small quantities of nitrates and ammonia are produced when there is thunder and lightning and these get added to the soil with rain water. Nitrates added to the soil remain as such and are either absorbed by crops or leached in drainage. Ammonia is absorbed by the clay in the soil and an equivalent amount of calcium is released by exchange of bases. This is later converted to nitrates and becomes useful to crops.

Organic manures decomposing in swampy soils produce ammonia as the end product, in which form alone

nitrogen is absorbed by the rice plant from swamp soils. When rice fields dry up, nitrates are formed and they are then absorbed by rice. If organic manures are ploughed in before stagnating water in wet lands, nitrates are produced as in dry lands, but they are denitrified when swamp conditions set in and escape as elemental nitrogen into the atmosphere.

Phosphorus is present in the weathered rock minerals and the soil, mostly as ortho-phosphate in an insoluble form and as organic phosphorus compounds associated with the organic matter in the soil. These are but sparingly soluble in soil solution and what is rendered soluble does not generally meet the requirements of vigorously growing crops, which get benefited by the application of phosphates.

Potassium is present in the soil as complex silicates which are insoluble and not available for the use of plants. Soluble potassium compounds, formed as a result of weathering and other chemical changes taking place in the soil, are fixed in the clay complex by ionic exchange with calcium. It is thus prevented from being leached away and remains available for the use of crops.

The role of major nutrients. Nitrogen is an important constituent of all plant cells and protoplasm. It is intimately connected with the vigour and growth of plants. When the supply of nitrogen in the soil is limited, crops make poor growth and their yields are low, but the proportion of the grain to the whole crop is maintained at a high level. When the supply of nitrogen is adequate, there is vigorous growth, the foliage is dark green, the leaf surface is increased and the final yield is satisfactory. Liberal supplies of nitrogen tend to prolong the period

of growth of crops and to delay maturity and ripening. Further, the thickness of the cell walls is reduced, the stems are weakened and they are not able to support the crops properly; there is lodging in cereal crops. There is rank growth of the leaves, together with crinkling on the surface. The resistance of plants to fungoid diseases is reduced, but this is offset to a large extent, when potassic fertilizers are also applied along with the nitrogen.

Phosphates hasten the maturity of crops, while nitrogen tends to retard it. When phosphorus and nitrogen are applied together, their specific effects on ripening and maturity balance each other and crops come to maturity in normal time.

Plants absorb phosphates mostly during the early stages of growth and phosphates have, therefore, to be applied at the time of sowing crops, or before.

The application of phosphatic fertilizers gives a marked response in soils, which are very deficient in phosphates. But their effects on crops are not spectacular as those of nitrogen, in general. All the same, the application of phosphates to land is considered necessary for maintaining a balance between the various plant food ingredients and for ensuring the normal growth of crops and production.

Potassium is taken up by plants largely in the early stages of growth. It increases the efficiency of the leaf in synthesising carbohydrates. How exactly it functions in this regard is not quite clear. It is particularly valuable for root crops and cereals, which lay by and store large amounts of starch in the tubers and the grains. It builds up in the plant system resistance to fungoid diseases, while generous supplies of nitrogen and the resulting rank

growth make plants susceptible. But, when the nitrogen is balanced by a sufficiency of potassium, the susceptibility to diseases is reduced considerably. This is an important and valuable property of potassium, connected with the nutrition of plants.

Time of application of manures. *1. Organic manures.* Bulky organic manures like cattle manure and compost have to be applied to land, 3 to 4 weeks before sowing the crop. The micro-organisms in the soil get active immediately after the application of the manure and multiply in large numbers. They require considerable nitrogen and indent on the soil nitrogen also, if the manures do not contain sufficient nitrogen. If the manures are applied at the time of sowing the crop, there is competition between the soil organisms and the young crops in their hunt for nitrogen. This is avoided when the organic manure is applied in advance. Intense multiplication and activity of the soil organisms are almost over by the time the sowing is done and the crop gets the nitrogen it wants, both from the soil and the manure.

2. Inorganic fertilizers. Concentrated fertilizers may be applied to lands at the time of sowing or even later. Plants absorb large quantities of manurial ingredients during the early stages of growth, and manures and fertilizers have to be applied to most crops, therefore, at or before sowing time. Crops do not require much of nitrogen and phosphoric acid later, and late applications are not ordinarily useful for short duration crops. Late applications of nitrogen may, however, increase the nitrogen content of the produce in certain cases, but it will at the same time prolong the growing period and the maturity of crops.

Crops with a long duration are in a different category. Their requirements of plant food are spread over a longer period and they benefit by the application of manure, not only in the early stages, but also later, in 2 or 3 doses at suitable intervals, depending upon their duration.

Dosage of manure. Manuring is done with the object of raising crop yields and maintaining the productivity of the land at a high level, by returning to the soil the plant food removed by crops. The manure applied on this basis has to supply plant food equal to what is removed by crops from the soil. In practice, nitrogen is added to the soil in amounts less than what is removed by crops. This is based on the assumption that fixation of atmospheric nitrogen, nitrogen added by rains, decomposition of organic matter and nitrification will supply the rest of the nitrogen required. If more nitrogen is supplied, it is likely to be lost in drainage or denitrified and wasted. More phosphoric acid than what is removed by crops is applied, as a part of the phosphate is fixed in the soil in insoluble forms and it does not become available for crops. South Indian soils are not deficient in potash and do not ordinarily require potassic manuring. Crops like coconut, potato, banana, chilli, *ragi* and tobacco which make a large demand on potash, are generally benefited by potassic manuring. Sandy soils are poor in potash and may respond to it.

The quantity of fertilizers and manures that is used depends on (1) the level of fertility of the soil, (2) the requirements of the particular crop, (3) the availability of moisture in the soil, (4) the cost of the manure and (5) the value of the produce. All these are taken into consideration at the time manures and fertilizers are

applied. The quantities of manures applied to important crops are indicated in the respective sections dealing with them.

Nitrogen applied during the early stages of growth of crops promotes vigorous vegetative development and the final yield is increased. When the supply is later, the maturity and ripening are delayed and there is not much improvement in yield. Late application of nitrogen may increase the nitrogen content of grains to an extent.

Phosphorus is associated generally with the production of grains. It is translocated to the developing grains from the other parts of plants and concentrated in the ripe grains. It is particularly effective in promoting the development of young roots and the root system. It promotes the formation and development of root nodules in leguminous plants, which are thereby enabled to fix atmospheric nitrogen vigorously and make good growth. This is of special value when leguminous crops are raised for the purpose of green manuring. The production of green material for use as manure is increased and the phosphates in the legume tissue also become available for the use of the succeeding crop.

Residual effects of manures. Organic manures are not completely utilised by crops in the year of application. Their effects persist for many years. Inorganic fertilizers leave some sort of residue in the soil, which may be beneficial, innocuous or even harmful, depending upon the substance applied. When ammonium sulphate is applied to land, the nitrogen in the fertilizer is absorbed by the crop and sulphuric acid is left behind. It reacts with lime and calcium sulphate that is produced as a result i

leached out. This reduces the lime content of the soil, and may lead to an acid condition of the soil when it is low. The soils in South India are well supplied with lime and the quantity of ammonium sulphate applied is so limited that it is not likely to bring about a deficiency of lime and lead to a condition of acidity of the soil.

When potassium sulphate is used as a fertilizer, the potassium is retained by the clay and sulphuric acid is released, which reduces the lime content of the soil like ammonium sulphate. Potassic fertilizers are not commonly or frequently applied as fertilizers in this country and loss of lime caused by potassic fertilizers is negligible.

The sodium in sodium nitrate is retained by the clay and this will affect the soil adversely, when the fertilizer is applied in large quantities year after year. Other fertilizers are without much residual effect.

Retention of manurial ingredients by soil. Manures and fertilizers contain both soluble and insoluble manurial ingredients. The latter are left behind in the soil and are not lost. Of the soluble ingredients, ammoniacal nitrogen, potash and phosphates are retained by the soil and they are not lost. Nitrate nitrogen is not retained by the soil and is liable to be lost in drainage during wet weather, when it is not used up immediately by crops. It may, therefore, be applied in split doses, to meet the immediate requirements of crops, but not excessively. When crops make vigorous growth, large quantities of nitrates may safely be applied, provided the weather is not too wet and showery. During the early and late stages of growth, crops do not require much nitrogen, and nitrates applied

then in excess of requirements are liable to be leached and lost.

When potassium, ammonium and sodium salts are applied to land, the bases form part of the clay complex and displace an equivalent quantity of calcium.

The soluble phosphates applied to soils may be acted upon in two ways. They may be reverted to insoluble forms as dicalcic and tricalcic phosphates, when the pH is over 6·5, or fixed as iron and aluminuim phosphates when the pH is below 5·5. A part of the phosphates is also retained by the humus in the soil by anionic exchange and partly as organic phosphorus; these are readily available for the use of plants.

Thus in a state of nature, the manures and fertilizers which are applied to land are retained in the soil in different forms for the ultimate use of plants. Nitrates are an exception and are liable to be leached under humid conditions, when they are not used up immediately by plants.

Function of fertilizers. Fertilizers have the very simple function of supplying elements of plant food, namely nitrogen, potassium and phosphorus, to make up their natural deficiencies in the soil. It will, therefore, be enough if the deficient ingredients are supplied to the soil, to the extent necessary, as crops cannot make satisfactory growth otherwise.

Function of manures. Organic manures added act on the soil (1) physically, (2) chemically and (3) biologically in many beneficial ways as follows:

1. Physically, organic matter promotes the formation of soil crumbs, makes the soil friable and thereby

facilitates the proper movement of air and water, and absorption of rains.

2. Chemically, it adds plant food to the soil and produces organic acids during decomposition, which act on the insoluble plant food reserves in the soil and make them available.

3. Biologically, it provides food for the soil organisms engaged in fixing atmospheric nitrogen and in producing nitrates from the soil nitrogen, for supply to plants in an assimilable from. If nitrification is suspended temporarily, crops do not make any growth during the period.

The supply of plant food by organic matter is not so important or so valuable as its effects on soil or soil organisms. Good soil management aims at building up organic matter for the maintenance of a suitable physical condition in the soil and producing an environment favourable for the activity of soil micro-organisms, which contribute to the productivity of land.

Supply of organic matter. The organic matter in the soil is rapidly oxidised under the high temperature conditions prevailing in the tropics. The roots and stubbles of crops left behind add a certain quantity of organic matter. Such additions vary widely and may range from 4 cwts. to 2 tons per acre ; it may be a fifth of the produce harvested in cereals and about a third in leguminous plants. Other plant residues like dried leaves shed by crops are limited, though they may not be negligible with certain crops like cotton and sweet potato. The material so added is not sufficient for maintaining the organic matter of the soil at a suitable level. Since it influences the properties of the soil and soil management

practices profoundly, the maintenance of organic matter in the soil at a fair level is important.

Use of fertilizers. Under the age old system of conservative farming, what was removed from the land was returned to the soil, in the shape of various farm manures. The fertility and productivity of the land were maintained at a low level even in advanced countries like England, Europe and America. Increased yields obtained today in those countries are secured by the liberal use of fertilizers, and yields are being pushed up higher to new levels. No other single agricultural practice has increased production as the efficient use of fertilizers.

Continuous use of fertilizers over a century, far in excess of what is likely to be used in farm practice, has not reduced the production of wheat in the continuous wheat plots at Rothamstead in England. Similar continuous applications amounting to 83 in number, during a period of 42 years, has not affected the production of the permanent manurial plots at Coimbatore, in any way. In fact, the complete fertilizer plot gives the highest yields among the various treatments. It excels the cattle manure plot, which has been receiving all the time more than twice the quantity of nitrogen. This should dispel the impression held sometimes that the use of fertilizers will affect the productivity of land at some time in the future; it will not. But, the injudicious application of large quantities of fertilizers beyond limit will however affect crop growth and production adversely, and this limit shifts with the soil, the crop, the season and the climate.

Supplementary functions of manures and fertilizers. Should manures or fertilizers be applied to land for

raising its productivity? This question is sometimes raised, but is unnecessary. Their fuuction with regard to the production of crops is different and they cannot substitute each other. Manures produce physical conditions in the soil favourable for the growth of plants, speed up chemical activity and provide food for micro-organisms, which are engaged in fixing nitrogen and in producing nitrates; the supply of plant food is comparatively a less important function. Fertilizers, on the other hand, supply plant food. Manures and fertilizers act differently and their functions are supplementary. Both raise the productivity of land, no doubt, but by different routes and the two together do it better than when they act singly and independently.

Regular use of fertilizers without the use of organic manures is not advisable. If organic matter is withheld completely, the physical condition of the soil will not be quite what it should be, and the maximum possible production may not be realised. Both organic manures and inorganic fertilizers have to be applied for obtaining the best results, the former to maintain the condition of the soil and the latter to raise the production efficiency. The application of both together is more economical than the application of the one or the other, individually.

The composition of manures is subject to wide variation and the following may be taken to represent their average percentage composition.

	N	P_2O_5	K_2O
1. Animal excreta, on air-dry basis			
Cattle manure	1·22	0·62	1·20
Goat ,,	2·40	0·90	2·00

	N	P_2O_5	K_2O
Sheep manure	1·93	1·30	2·30
Fowl ,,	0·92	1·88	0·60
Horse ,,	0·70	0·69	0·83
Bat's guano	8·00	2·60	1·00
Poudrette	6·20	2·90	0·70

2. Green material, on air-dry basis

Daincha (*Sesbania aculeata*)	3·50	0·60	1·20
Sesbania speciosa	2·71	0·53	2·21
Wild indigo plant (*Tephrosia candida*)	1·80	0·20	0·60
Cassia siamea leaf	2·24	0·40	1·31*
Cassia auriculata	2·86	0·64	2·48*
Pungam leaf (*Pongamia glabra*)	3·31	0·44	2·39*
Calotropis gigantea leaf	2·10	0·70	3·60
Gliricidia maculata loppings	2·90	0·50	2·80
Forest leaf (mixed type)	1·20	0·60	0·40
Sea weeds	1·10	0·30	3·00
Redgram plant (*Cajanus indicus*)	2·80	0·40	2·00

3. Various earths, on air-dry basis

River silt	0·30	0·40	0·70
Tank silt	0·30	0·30	0·30
Village earth	0·40	0·40	0·30
Earth scraped from cattle shed	0·20	0·10	0·70
Potassic earth from mud walls	0·20	0·70	1·30

4. Concentrated organic manures, on original moisture basis

Groundnut cake	7·60	1·30	
Castor cake, white	6·30	2·60	1·10
Castor cake, black	4·50	1·80	0·70
Pungam cake	4·20	0·90	

* Unpublished data.

	N	P_2O_5	K_2O	CaO
Neem cake	4·70	1·90		
Gingelly cake	6·10	2·40		
Safflower cake	5·50	1·40		
Coconut cake	3·50	1·40		
Leather shavings	8·40	0·10		
Hoof meal	12.80			
Horn meal	14·00			
Fish guano	6·80	7·10		
Bone dust	3·70	24·50		31.30
Steamed bone meal	4·40	23·60		41·80
Bone char	1·00	29·90		38·30

5. Nitrogenous fertilizers

	N	P_2O_5	K_2O	CaO
Sodium nitrate	15·50			
Ammonium sulphate	21·60			
Ammophos	11·00 to 22·00	60·00 to 52·00		
Potassium nitrate	10·50		37·00	

6. Phosphatic fertilizers

	N	P_2O_5	K_2O	CaO
Basic slag		17·20		45·00
Superphosphate, ordinary		22·00		
Superphosphate, double		43·00		
Potassium phosphate		23·00	17·00	
Trichy phosphate		22·00		54·00
Flour phosphate		23·00		50·00

Sources: Pamphlet No. 9, Madras Agric. Dept., 1936, Leaflet No. 7, Madras Agric. Dept., 1935, and Note book of Agricultural facts and figures, Madras Agric. Dept., 1952.

7. Potassic fertilizers

	P_2O_5	K_2O	CaO
Potassium sulphate		43·00	
Potassium chloride		53·50	
Kainit		12·50	
Wood ash	1.50	4·00	22·00
Cotton stalk ash	1·80	9·40	28·60
Rice husk ash	0·50	0·30	
Cow dung ash	2·00	0·70	

The quantity of manurial ingredients removed on the average by some important crops, in pounds per acre, is as follows :

Name of crop	N	P_2O_5	K_2O	Remarks
Rice	48	23	41	
Sorghum	72	25	45	
Ragi	49	30	202	
Wheat	37	13	20	
Varagu	23	10	17	
Cumbu	28	10	11	
Maize	25	10	25	
Tenai	19	8	22	
Potato	47	22	77	
Cotton	97	29	83	
Sugarcane	56	68	190	(25-ton stripped canes.)
Tobacco	67	9	85	(1,000 lb. cured leaf.)
Coconut	24	12	60	(2,000 nuts per year.)
Banana	200	80	800	(800 trees per acre.)

CHAPTER III

TILLAGE

Tillage. Tillage is the manipulation of the soil with tools and implements, for loosening the surface crust and bringing about conditions favourable for the germination of seeds and growth of crops. Cultivation of the soil is done in various ways, in different places, with implements of diverse kinds. The cultivation practices in vogue in the several regions in India have been evolved by farmers with generations of experience behind them. They have been devised to suit the several soil conditions, the requirements of the different crops, the vagaries of climate and last, but not the least important, the resources of farmers and small peasants. They have remained practically unchanged for a long time now. Cultural practices have, on the other hand, undergone considerable changes during the past 50 years in the Western countries, largely as a result of shortage, or/and rise in the cost of labour and of the impact of industry and engineering on agriculture. Mechanisation of most agricultural operations has been developed and it has taken away the tedium out of the monotonous farm work.

Objects of tillage. The main objects with which tillage is done are :

1. to produce a satisfactory seed-bed, suitable for the germination of seeds,

2. to provide conditions in the soil, which favour the growth of crops,

3. to remove weeds,

4. to make the soil capable of absorbing rainfall,

5. to incorporate manures and fertilizers with the soil, and

6. to aerate the soil. The aeration of the soil is done to activate the plants and the beneficial micro-organisms living in the soil. It promotes the evaporation of moisture in the soil and enables the soil to get warmed up sufficiently in temperate countries. The soils in the tropics are sufficiently warm and their cultivation is not done with the object of warming up the soil. Incidentally, the cultivation operations expose egg masses, larvæ and pupæ of insects that may be inside the soil to sun light and bring about their destruction. Crows may often be seen hovering over ploughed land, to pick up the insects that are exposed.

Tilth. Land, brought to a condition suitable for germination of seeds and growth of crops, is called 'seed-bed' and it is said to be in good tilth. Tilth refers to the loose, powdery, granular and crumbly condition of the soil made favourable for the germination of seeds and growth of crops. When the soil is felt between the fingers, the soil granules are soft and friable and crumble under pressure. The loose soil is made up of powdery material and soil granules. The granules are aggregates of soil particles held together loosely, but in a fairly stable form. The presence of granules or crumbs, 1 to 5 mm. in size, is considered to be favourable for the growth of plants. The crumbs provide adequate aeration and facilitate absorption of rain water by the soil. The fine particles tend to clog the soil pores and big clods

include large air spaces and do not permit or favour the development of young rootlets in plants.

Tilth may refer to different soil conditions. Its concept varies with the crop and the soil. Crops with small seeds like *ragi*, onion, lucerne and the like require a fine seed-bed. The seeds do not germinate properly when the seed-bed is in a coarse condition. Soil in a fine powdery condition alone will be said to be in good tilth then. On the other hand, crops like sorghum do well only when the seed-bed is firm. Big seeded crops like cotton, Bengalgram, lablab etc., require a coarse seed-bed and coarsely tilled soil will then be considered to be in good tilth.

Tilth in relation to the soil. Red soils are sandy or loamy and they are brought easily to a powdery condition, for taking up sowings with the first rains of the season. The powdery condition does not affect the capacity of the soil to absorb rains, as it is composed of coarse particles and the pores in between are wide enough to permit easy absorption and infiltration of water. The black cotton soil, which is clayey, is left in a rough cloddy condition to facilitate rains being retained on the surface, till it is absorbed. If the soil is left in too fine a condition by repeated ploughings, the surface gets caked up when it dries after a rain. It is then unable to absorb rains received later and a large part of the rain water flows over the land and runs to waste, without increasing the moisture in the soil.

Soil condition suitable for cultivation. When soil that has got compacted during a crop season is first ploughed with the moisture at the correct level, it crumbles down to a rough powdery state. The cultivation done at this

stage also facilitates the work being done with the least expenditure of energy. When a small quantity of soil at the correct level of moisture is pressed, keeping it in the hand, a ball of earth is formed. If this is dropped on the ground from a height of about 3 feet, it disintegrates and the constituent particles fall apart. If the soil is too moist, the particles do not get separated and the ball gets flattened out. If the soil is too dry, the particles do not hold together and form a ball. Ploughmen, with years of experience, distinguish easily the most suitable stage for taking up ploughing and other cultivation operations.

Preparatory and after-cultivation. Tillage operations done to fields from the time of the harvest of a crop to that of sowing the next one go by the name of 'preparatory cultivation'. They aim at the production of a loose and powdery condition of the soil, suitable for the growth of crops. In a good seed-bed, the loosened layer is in contact with the compact soil below, which facilitates the movement of moisture and the development of roots in the soil. Operations done to the fields after sowing till the harvest of the crop go by the name of 'after-cultivation' or 'interculture.' These assist in loosening the surface soil and in removing weeds.

Tillage implements. The implements used for preparing the land in South India are few. The indigenous wooden plough is ordinarily the only implement used for the purpose. It is worked repeatedly on the land at intervals, till the soil is brought to the desired condition. Blade harrows, called *guntakas* and drills called *gorrus,* but without the arrangement for distributing the seed, are used instead of the plough, for

preparing the land in Andhra Desa, particularly in Deccan.

The indigenous wooden plough. This consists of a wooden body, to which are attached a handle or stilt and a shaft pole. The body is made of a bent piece of hard wood, with its two arms making an angle of about 135°. A small piece of flat iron, called the 'share', serves as the piercing point of the plough and it is fixed to the plough body with two cleats of iron.

When the plough is worked in the field, it enters the soil under the wedge action of the body and makes 'V' shaped furrows; the soil is split and pushed on both the sides to make room for the body. Unploughed ridges of land are left in between adjacent furrows and the land is completely stirred and moved only when the land is ploughed twice or thrice. The soil is stirred to a depth of 3 to 5 inches, depending upon the size of the plough. The depth and width of the furrows are more or less constant for each plough, though the depth can be adjusted a little with the distance between the plough body and the yoke.

The wooden plough is generally the only implement the peasant has. It is used for opening up the soil, for covering manure and seed scattered over the field, for intercultivating wide spaced crops like redgram and for thinning certain crops like *cumbu*. It is also used occasionally for opening furrows by wedging in a wooden block between the body and the shaft pole; the body then scoops the soil and opens furrows.

The wooden plough can be used under a wide range of soil conditions, except when the soil is very dry and hard to break. It can be worked even when the soil is very

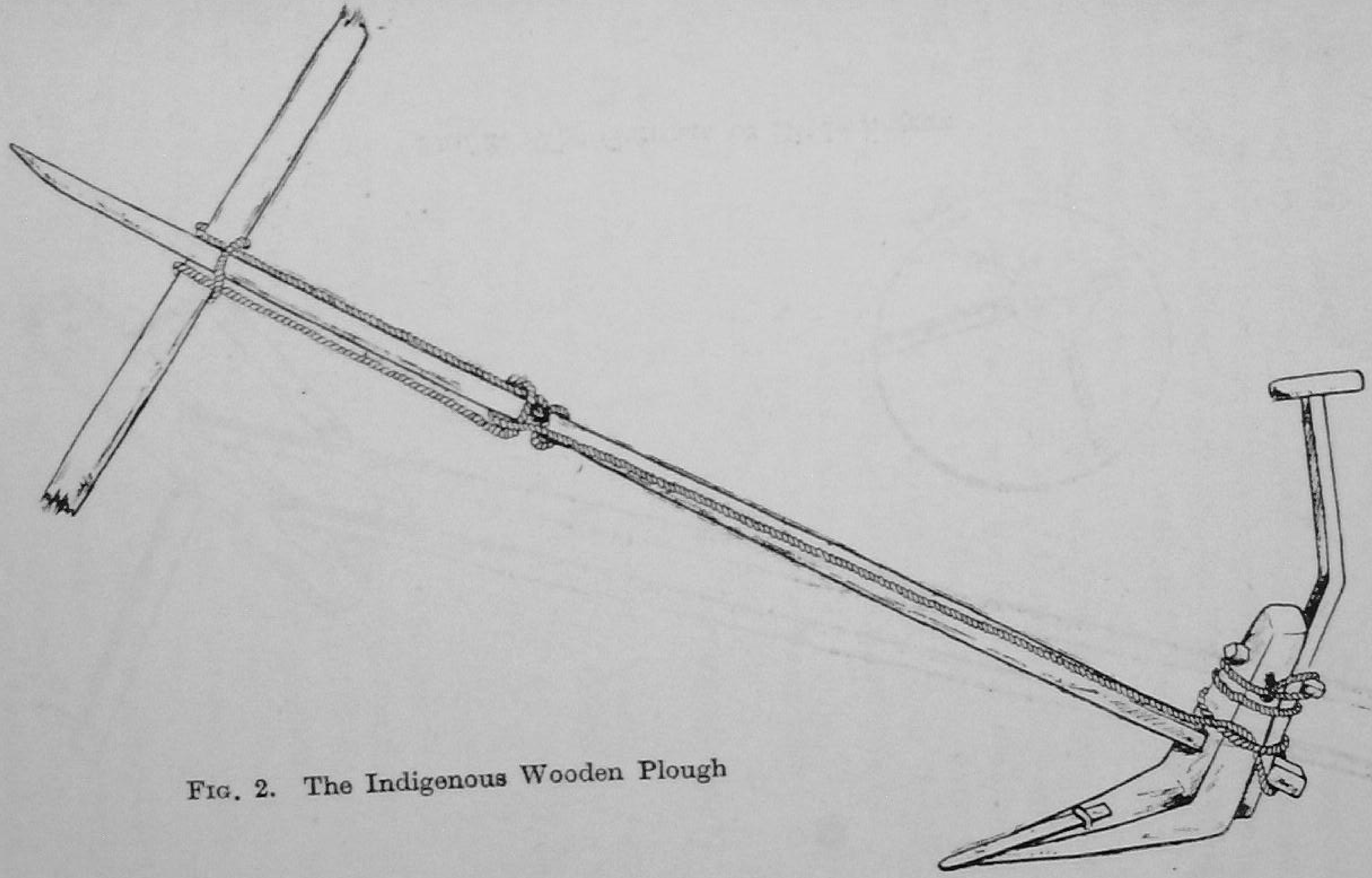

Fig. 2. The Indigenous Wooden Plough

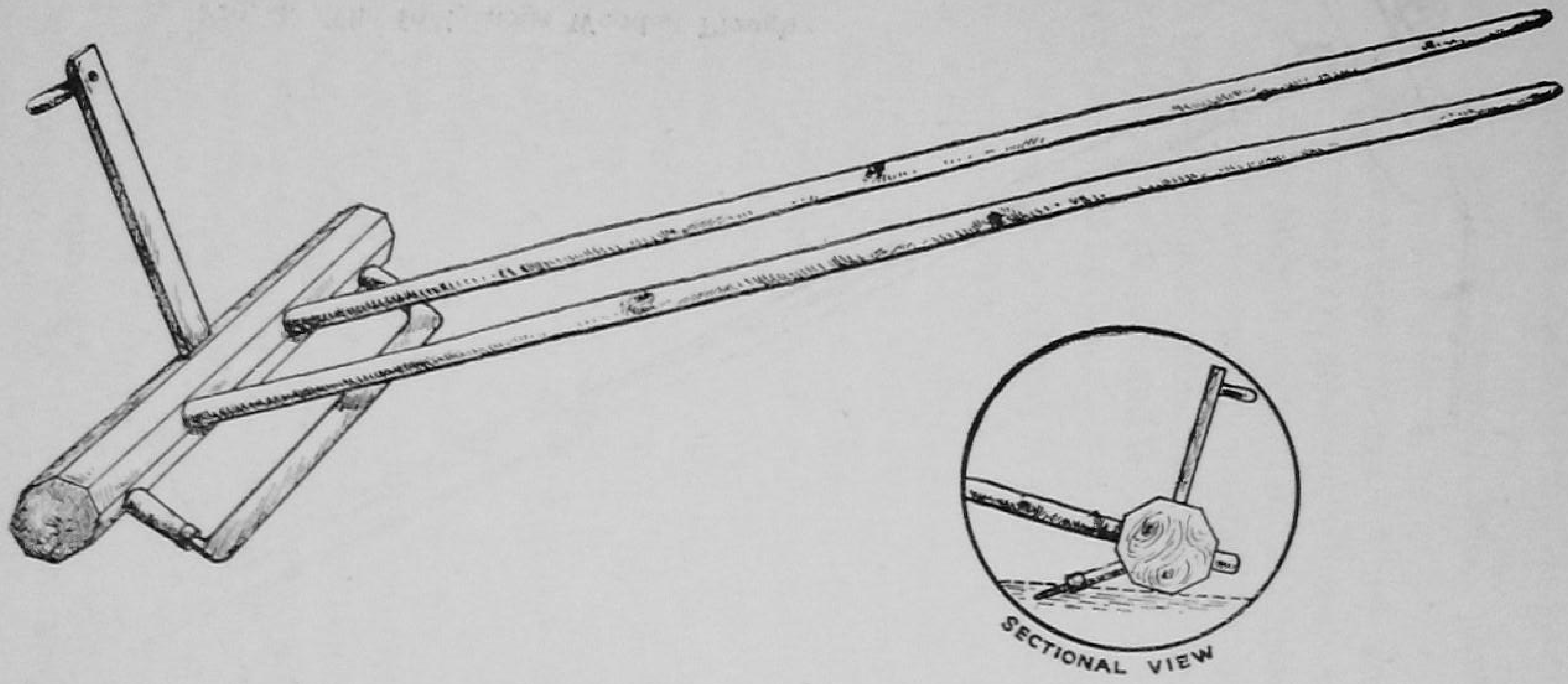

FIG. 3. The Guntaka or Blade harrow

wet, if necessary. This assumes importance in regions of uncertain rainfall, where crops have to be sown as soon as possible after rains, to avoid missing the season. Iron mouldboard ploughs cannot be used under such conditions; they puddle the soil and leave it in an intractable state for some time.

The wooden plough is firmly entrenched in the Indian farming system. The plough is made from odd pieces of wood available in the farm and the cost of making is negligible. If it gets out of order, the village carpenter sets it aright easily. Minor repairs can be done by the peasants, without the assistance of carpenters. It can be carried by one man easily, taken to the field on work days and brought back home, to be stowed away in a safe place. All these make the wooden plough the first choice of the Indian peasant and the iron plough is at a disadvantage from these points of view.

The guntaka. It is a blade harrow, which is commonly used for preparing the land in the Ceded districts, instead of the plough. A horizontal beam about 6 inches across is the main frame, to which are fixed the handle, the shaft pole and the harrow blade, as shown in figure No. 3. The blade is fixed to the beam near the ends, at a distance of about 10 inches, with two standards. The blade is 3 feet long, 3 inches broad and 1/3 inch thick, with a cutting edge in front. Big sized *guntakas*, 6 feet wide, called *bara guntakas* are also in use. Small ones, called *dantis*, (Fig. 4, P. 45), are used for intercultivating row crops.

The horizontal blades of the blade harrows enter the soil and travel below the surface at a constant depth, in the direction of motion of the implement. They sever the surface layer from the soil below and leave it in its

original position. The separated layer is but slightly disturbed. At the same time, the weeds in the field are also cut from under the surface of the soil. This eradicates all the weeds excepting those which have underground bulbs. Some of the common types of blade harrows are illustrated in Fig. No. 5, P. 46, and their local names are furnished under each.

The gorru. This is the local seed - drill of Andhra Desa, consisting of a horizontal beam with a number of tines (tynes) fixed at suitable distances from one another. The tine is like the body of the wooden plough and much smaller. There is a seed hopper above, where the seed is released, a little at a time with the hand. The base of the hopper has as many holes as there are tines in the *gorru* and narrow bamboo or metal tubes connect the hopper and the tines. This enables the seeds released in the hopper being dropped in the furrows opened by the tines. The hopper and the seed-tubes are held in position with thin ropes, as shown in Fig. No. 6, P. 47.

There are different sizes of *gorrus* suitable for sowing different crops. Heavy drills with 3 big tines are used for sowing big seeded crops like Bengalgram, deep in the soil. *Gorrus* with 6 medium sized tines are used for sowing sorghum and most other crops. Light *gorrus* with 12 small bamboo tines are used for sowing *ragi*.

The mouldboard ploughs. The ploughs, in use in the Western countries originally, were like the Indian indigenous ploughs in general design and were made of wood. Iron ploughs were designed towards the close of the 18th century and perfected during the 19th century. Considerable improvements have been made in plough design during the last 40 years along with the develop-

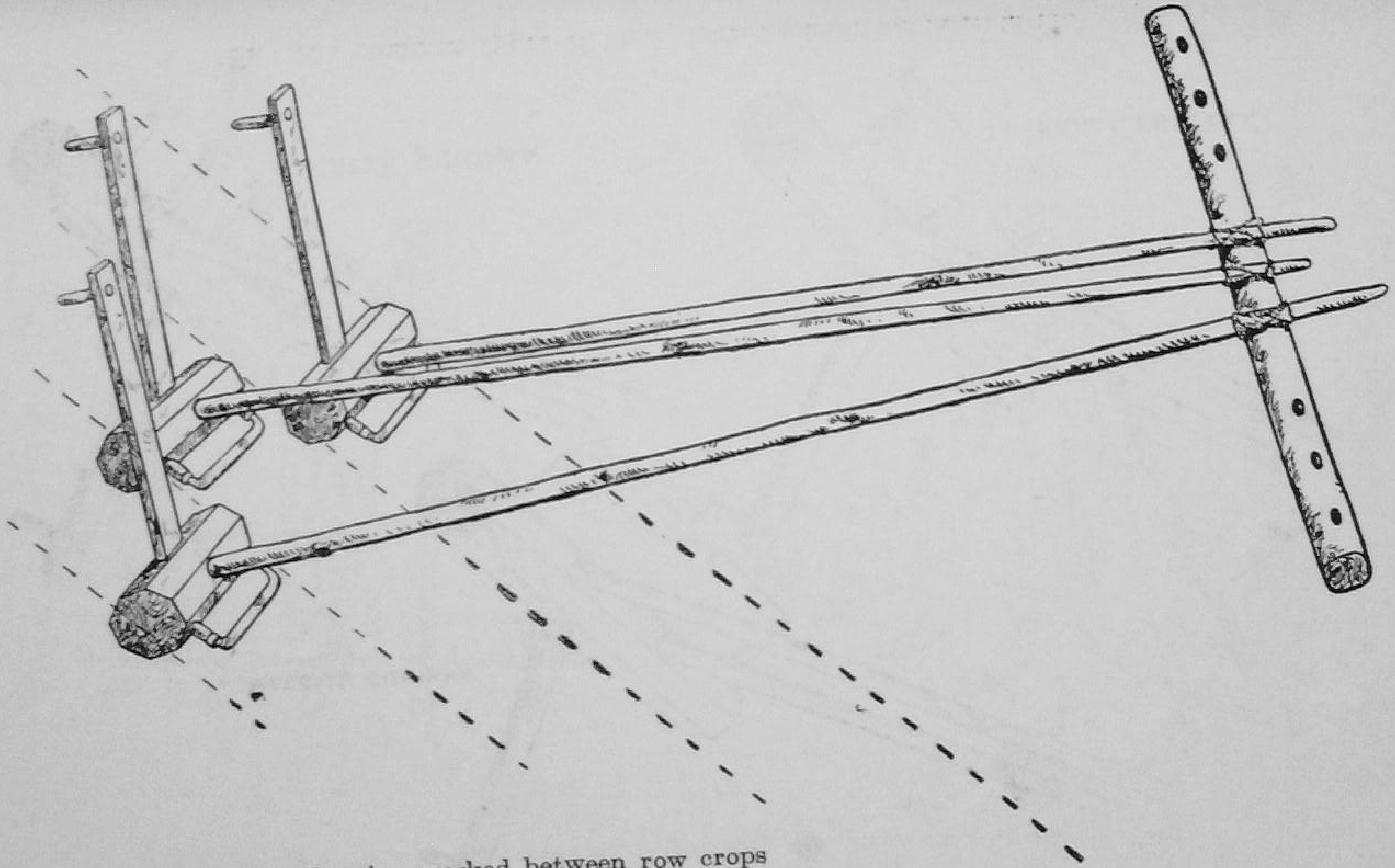

Fig. 4. Danties, worked between row crops

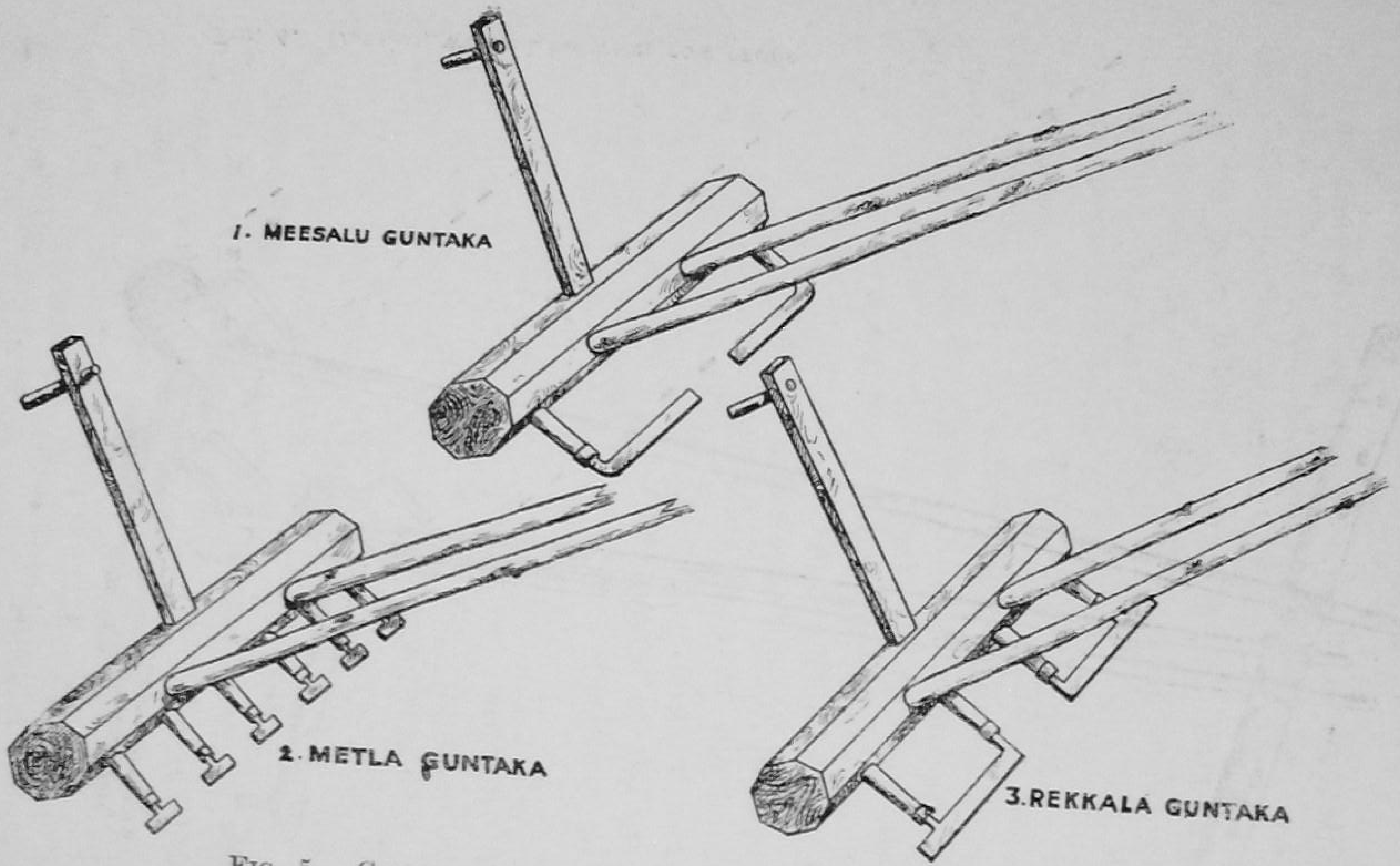

FIG. 5. Common types of blade harrows used for interculture

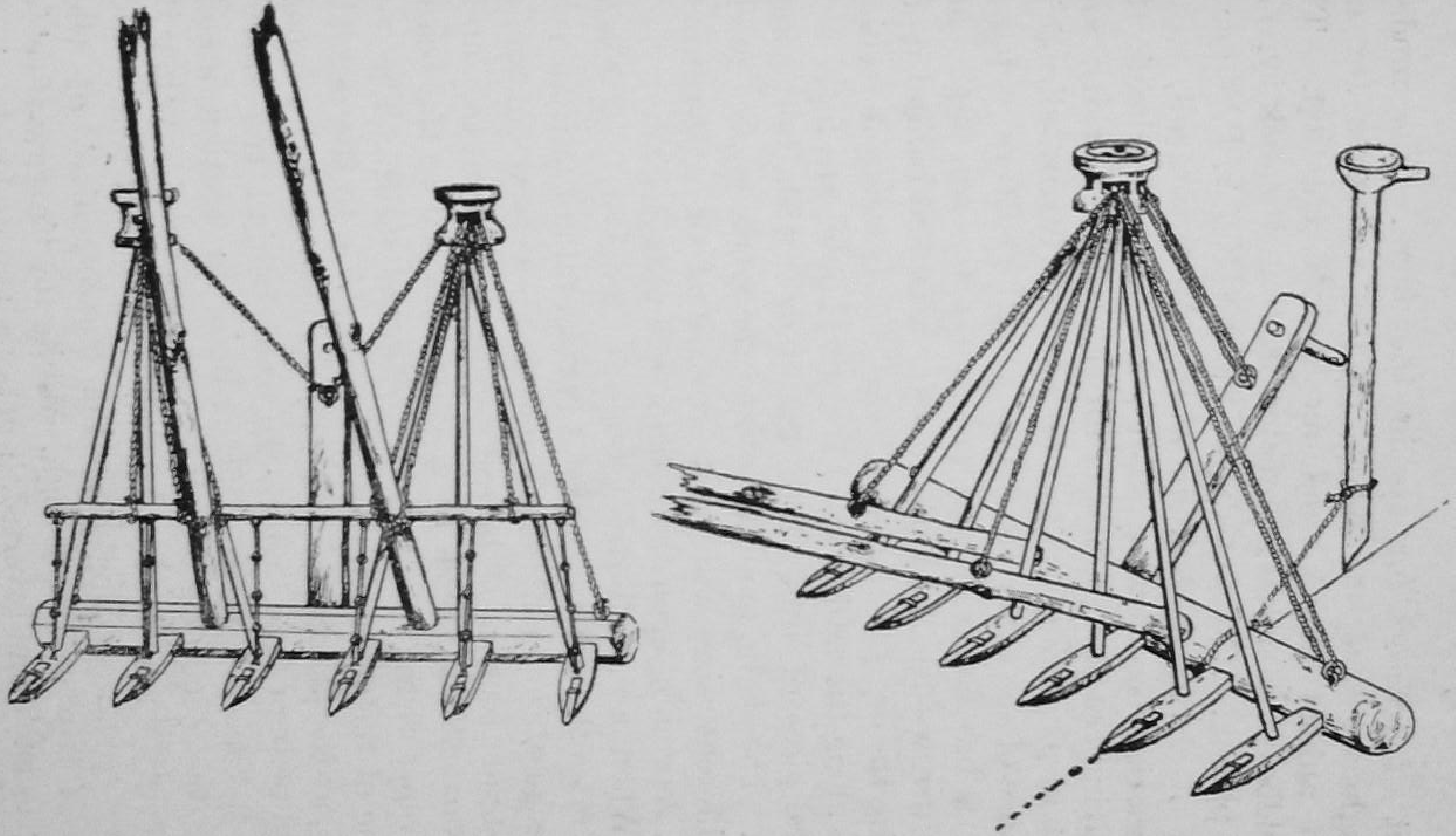

FIG. 6. Gorrus or indigenous seed drills, with one and two seed hoppers, and an akkadi tied to the second tine of the *drill* on the right

ment of tractors for use in the farm. The modern ploughs are made in various designs and sizes for use with animal power and mechanical traction. The mouldboard plough is in greater use than the disk type of iron plough. The mouldboard plough (Fig. 7. P. 49) consists of a plough bottom, which enters the soil, with accessories like handles, shaft poles, beams, wheels for steadying the plough, bridles for adjusting the width and depth of ploughing, coulters for cutting 'furrow-slices' in advance of the share etc. The plough bottom consists of (1) a broad share which penetrates the soil and cuts the 'furrow-slice,' (2) a mouldboard attached behind it to receive the cut 'furrow-slice' and (3) a landside which slides along the wall of the furrow. These are fixed to a central piece of iron called the 'frog', with bolts and nuts. The share, mouldboard and the landside are made in different sizes with cast iron, steel or soft-centred steel, depending upon the costliness of ploughs.

When a mouldboard plough is worked, the share penetrates the soil and makes a horizontal cut as it moves. The edge of the mouldboard makes a vertical cut and a rectangular section of the soil is separated from the land. The vertical cut is made by coulters attached to the beam in advance of the share in the costlier ploughs. The cut section of the soil passes on from the share to the mouldboard, as the plough moves. The mouldboard is a broad curved plate of iron, which is fixed behind the share, with its back part raised. The ribbon or section of soil cut by the plough is called the 'furrow - slice'. When it traverses the mouldboard, it is twisted, inverted and laid upside down, resting over the 'furrow-slice' of the previous trip of the plough. While the 'furrow-slice' is being twisted and inverted, it gets broken and pulverised

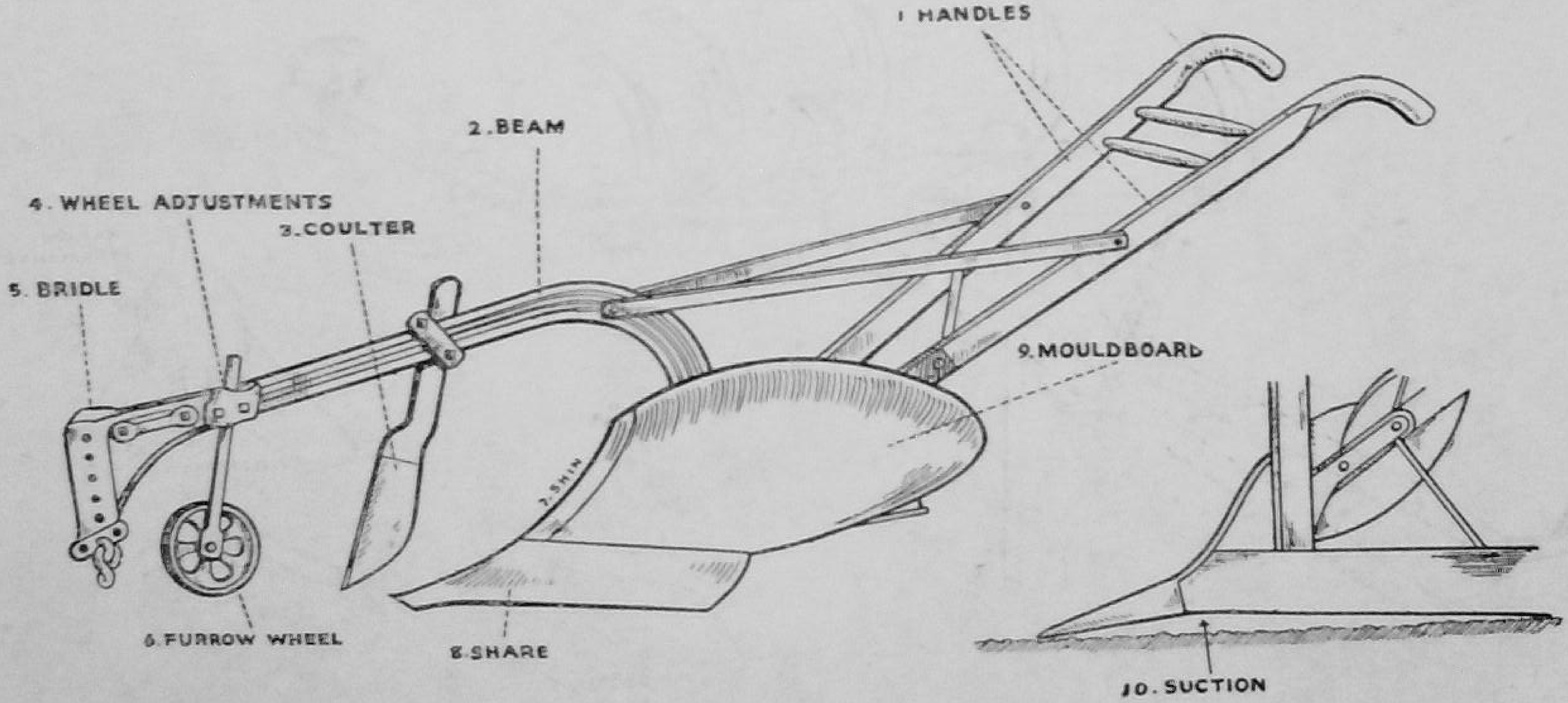

FIG. 7. An iron mouldboard plough

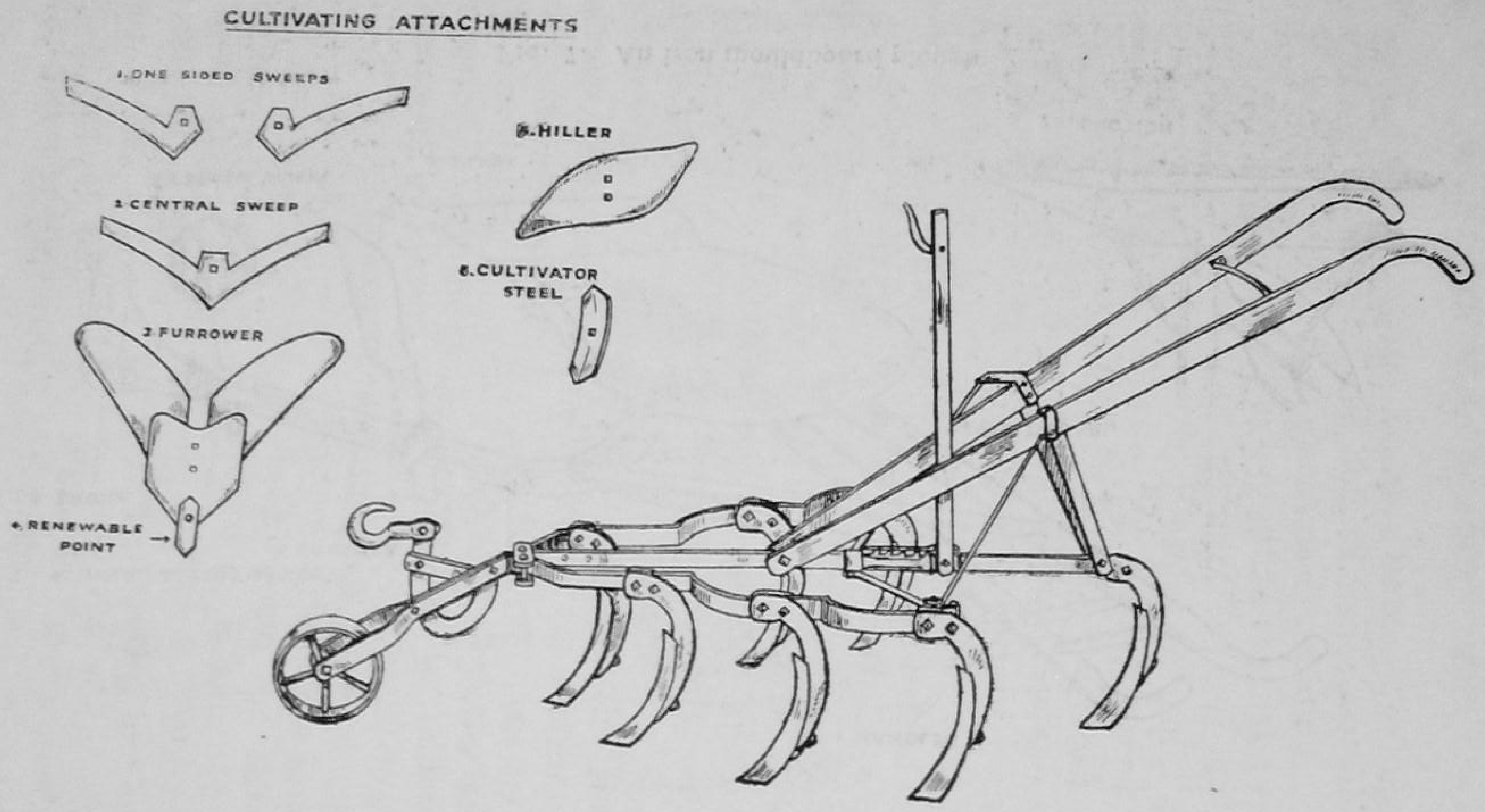

FIG. 8. Intercultivator, or bullock hoe, worked between row crops

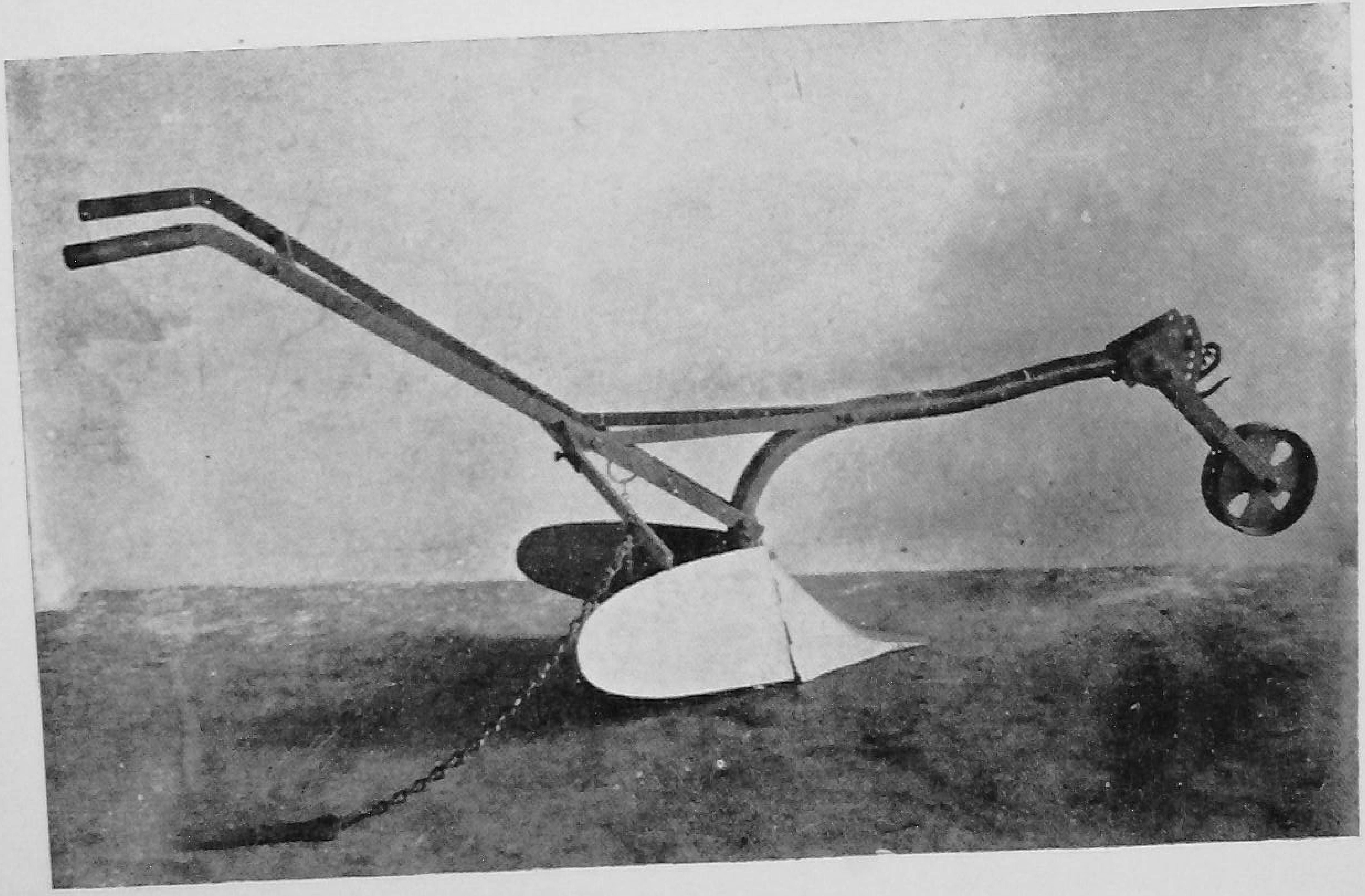

FIG. 9. The Ridge Plough.

—Courtesy: Director of Agriculture, Madras.

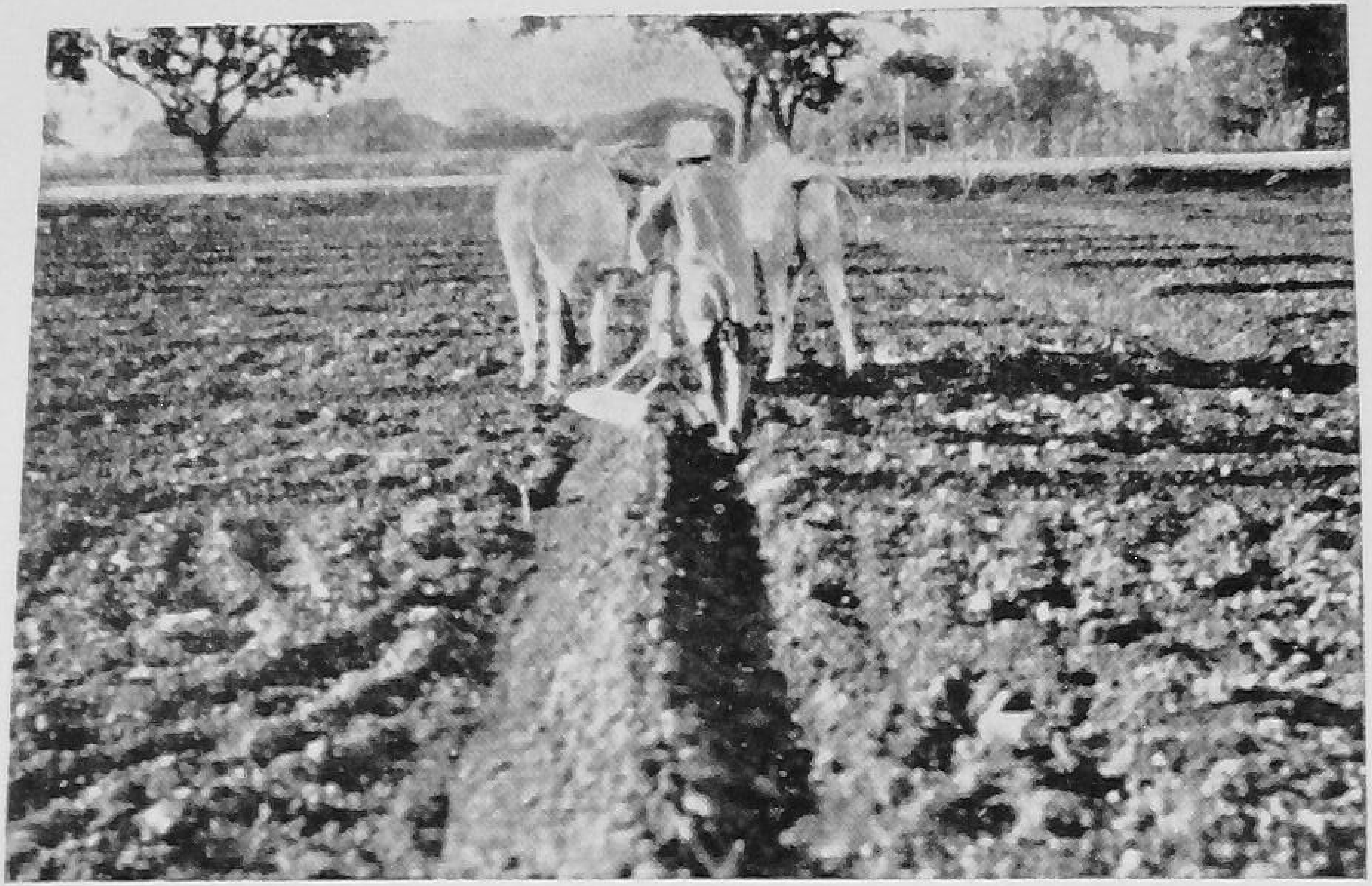

FIG. 10. Bunds formed with bund-former.

—*Courtesy : Director of Agriculture, Madras.*

to some extent, depending upon the shape and curvature of the mould board. A long mouldboard with a gentle curvature leaves an unbroken furrow-slice in an inverted position, while a short mouldboard with an abrupt curvature leaves the furrow-slice in a more or less pulverised state.

Cutivators and harrows. These are implements which have a number of steel tines fixed to a frame work. When these are worked over a ploughed field, the tines get into the soil and break the clods formed during ploughing. The cultivators are heavy implements sturdily built, with strong long tines set wide apart, for breaking big clods. The harrows are smaller in size and have short tines set close to one another. They are worked after the lands are worked with cultivators and the big clods are broken. They break the small clods on the surface and bring about pulverisation of the surface soil. The mouldboard ploughs, cultivators and harrows are not in ordinary use in India. An intercultivator is shown in p. 50.

The ridge plough. This is a double mouldboard plough, with mouldboards on both sides, meeting along the centre. The ridge plough (Fig. 9. facing p. 52) opens furrows and lays the earth from the furrow on both sides. The name given to it is a misnomer, as it opens furrows alone and does not form ridges. When, however, furrows are opened close to one another, the inter-furrow spaces take the form of ridges. When furrows are opened wide apart for planting sugarcane and similar crops, the inter-furrow spaces take the form of raised beds.

The bund-former. It consists essentially of a pair of opposing wings, which are wide apart in front and converge towards the rear, with a gap at the end. The wings

gather loose soil from the surface and leave it in the form of a bund in the wake of the implement. The size and disposition of the wings are such that the bund formed is about 7 inches in height. The bunds are smaller in size, when the wings are slightly raised at the fore end and pulled a little backward. When the implement is hitched near the yoke, a small quantity of earth alone is gathered.

The implement is worked along the field and across at suitable intervals, for enclosing rectangular spaces or beds, as shown in Fig. 10 facing p. 53. Gaps, formed at the intersection of the long and cross bunds while working the implement, are closed with manual labour. Irrigation channels for leading water to the beds are formed with two bunds close to each other. Ridges for sowing cotton and similar crops are also formed with the bund-former, with the bunds close to one another, when furrows are formed between adjacent bunds.

Factors influencing preparatory cultivation. The preparatory cultivation of the land is done in different ways. It is influenced by several factors, and the more important ones are (1) the crop grown, (2) the type of soil, (3) the prevailing climate and (4) the type of farming.

1. The Crop. The crop more than any other factor decides the type and extent of preparatory cultivation given to the land. Hardy crops like sorghum and other millets are not very sensitive about tilth; production of fine tilth by repeated cultivation increases the cost of cultivation without any corresponding rise in production and is not economic. Delicate crops like tobacco, chilli, coriander etc., require a fine seed-bed and the land has to be repeatedly worked, till the required fineness of tilth

is secured. Sugarcane and root crops respond very well to deep cultivation and lands are often dug with spades and crowbars to loosen the soil to the required depth.

2. *Type of soil.* Clayey soils are amenable to cultivation, within a narrow range of moisture only. They cannot be worked satisfactorily outside this range, as the draught required for cultivation is increased thereby. The soils get broken down to small clods and further cultivation is without much effect. The lighter soils can be worked under a wide range of conditions and the draught required for their manipulation is much less. Loamy soils are brought to good tilth with little cultivation and expenditure of energy.

3. *Climate.* Climate influences the moisture in the soil, the draught required for cultivation and the depth and type of cultivation done. For example, the Ceded districts region has a low rainfall and the moisture in the soil prior to sowing does not permit deep cultivation, which tends to dry up the soil to a greater depth and reduce the moisture available to crops eventually. This is disadvantageous, particularly in years of low rainfall. Sowing cannot be done till the full depth of the cultivated soil is moistened adequately. It is consequently delayed, which reduces the growth and the yield of crops. Deep cultivation is without much adverse effects in regions which have a better rainfall. It is often done in temperate regions, for promoting aeration.

4. *Type of farming.* Intensive cropping is done in garden lands, which have irrigation facilities. Crops follow one another closely and cultivation operations are done with little interval between them. Thus, the soil is not subject to natural weathering for long periods, so that

cultivation is more important in bringing about tilth than weathering. The frequency and extent of tillage operations increase the cost of cultivation, but this is not serious in garden lands, where commercial and profitable crops are raised in an intensive manner.

In dry lands, which depend entirely on rains for the supply of moisture, only one crop is raised each year and the interval between crops and successive cultivation operations is long. Weathering plays an important part, and the role of cultivation in promoting tilth is less important. Cultivation operations are limited, with wide intervals between them. The cost of cultivation is kept down and the low productivity of land does not warrant a higher expenditure.

Extent of tillage necessary. The iron mouldboard plough originated in Europe, where its utility was accepted without question. It buried the stubbles and weeds inside and left the soil in a clean condition. Farmers felt that ploughing was being done efficiently. It was next assumed that deep ploughing would be more efficient and it came into vogue. It was assumed to confer advantages, which were accepted as correct without question. The European climate did not show any adverse effects, as a result of deep ploughing, which buries weeds properly, improves aeration and drainage, and promotes bacterial and chemical activity in the soil. But its effects are not fully known. Deep ploughing was not, however, any better than ordinary ploughing in raising the production of crops in weed-free fields at Rothamstead.

The South Indian soils have not lost their tone and productivity even under long cultivation. The cultivation methods in vogue have maintained a balance between the

soil, the climate, the environment and the resources of the peasants. They should, therefore, be considered to be sound in a general way, taking all the factors into consideration, though they may appear primitive by the side of mechanical cultivation. If American experience of lands laid waste by injudicious cultivation is any guide, we should beware of the possible ill effects that can follow deep ploughing and frequent tillage with mechanical equipment in the name of efficiency. They leave the land in a clean state and give the impression that the soil is being cultivated efficiently. That it may oxidise the organic matter in the soil rapidly, lower the productivity of land and lead to soil erosion and blowing, is possibly not given adequate consideration. Doubts have been cast by soil scientists in recent years, on the utility of inversion ploughs and deep ploughing. The question is being pursued in western countries and a definite answer will be available in due course. Since it is not improbable that deep ploughing can lead to deterioration of the soil, at least under certain conditions as in parts of U. S. A., deep ploughing with mechanical or cattle power should be attempted only after its effects on soil are fully studied in all aspects under tropical conditions and its benefit or utility proved beyond doubt.

Tillage requirements in South India. Recent studies of primary tillage made at the agricultural stations in Madras and Andhra states indicate that the methods of cultivation practised by farmers in the several regions are basically sound, though they can be improved upon in certain aspects. The indigenous wooden plough, light iron ploughs going into the soil to a depth of 5 inches, heavy iron ploughs going up to 8 or 9 inches and *guntakas* were used for determining the optimum tillage required at

Hagari, Nandyal, Koilpatti and Coimbatore. The rainfall in these stations is low and only just sufficient for crop production. The several implements were worked alone and in combination with one another, and ranging from one to nine times. No treatment was consistently superior to others, not even superior to the treatment, where the land was not given any primary tillage. It may, therefore, be deduced that primary tillage is without distinctive or specific influence on the productivity of land. But the soil has to be brought to a condition suitable for sowing being taken up immediately after the receipt of seasonal rains. Primary tillage has, therefore, to aim at the production of a suitable seed-bed free of weeds, in areas of low rainfall, with a minimum of cultural operations and effort. A distinction has to be drawn between the preparatory culivation that is necessary for the production of a proper seed-bed and spare time operations done by peasants, which are not absolutely necessary.

Too much of cultivation makes the soil loose and may be deleterious under certain conditions. Frequent tillage and cultivation of row crops like cotton and corn have subjected American soils to erosion by wind and rain. Where strong winds or torrential downpours of rain may be expected, it is not advisable to leave the soil in too loose a condition. Such a seed-bed is not suitable for certain crops like sorghum. The germination and stand of sorghum are poor in well tilled soils, particularly in years of heavy rainfall, while they are satisfactory in coarsely tilled soils.

In tracts of adequate and timely rainfall, generous cultivation may be helpful. The Guntur tract along the

Coromandel coast is favoured with good rainfall, both during the south-west and north-east monsoon periods. The farmers plough the land 4 times and work *guntakas* and *gorrus* alternately twice each. It has been noted that reducing this preliminary tillage brings about a corresponding reduction in the yield of crops.

Cultivating the soil to varying depths and frequency may thus bring about different effects on crops in different regions. What is suitable for one set of conditions need not necessarily be so under different conditions of soil and climate. It may be taken that ordinarily, the method of cultivation and their frequency in vogue in the several regions are suitable and sound, having been evolved through centuries of practical experience. Violent changes in the type of cultivation need not necessarily be more efficient and the effects of any change have to be studied in all their bearings, before they are advocated extensively. Experience gained in the methods of tillage in other places and countries is not always helpful and may even be misleading.

Interculture. It produces a mulch on the surface of the soil and it was presumed incorrectly in the earlier years that it destroyed effectively the capillary passages connecting the lower layers of soil with the surface and and consequently its evaporation there. Capillarity is not capable of lifting water from the lower layers to the surface, except where the water table is within 3 feet of the surface, a condition which does not exist in South India. Intercultivation conserves moisture in quite a different way. It uproots the weeds and thus prevents the loss of moisture from the soil through their transpiration. Weeds spring up heavily in years of

continuous rains and frequent interculture may then be necessary. It is not improbable that soil mulch may control the temperature of the lower layers of soils in the tropics. The loose mulch cannot conduct heat to the lower layers so well as a compact surface. The effect of soil mulch on the regulation of soil temperature and on crops in South India remains to be studied.

In the black soils of Deccan, cracks develop and extend to a considerable depth with the onset of hot weather, thus promoting the removal of moisture from the lower layers of soil. Interculture and production of a soil mulch retard the development of cracks and may be of assistance in reducing the loss of moisture from the soil.

Interculture can thus have different effects, namely (1) removal of weeds, (2) production of a soil mulch, (3) promotion of the absorptive capacity of the soil for water, (4) regulation of the temperature of the soil layers and (5) prevention of the development of cracks and loss of moisture through them. It may assume importance with regard to one or more of these effects, depending upon local conditions.

CHAPTER IV

IRRIGATION

Irrigation. Irrigation is the artificial application of water made for supplementing the moisture in the soil, when it is deficient and does not meet the full requirements of crops. Moisture is supplied to the soil mainly by rainfall, which is however variable and which may not be sufficient or timely always. Crops do not make normal growth when the moisture in the soil is low. When the moisture is more, the supply of air in the soil is reduced correspondingly, which limits the growth of plants. In between, there is a range of moisture content, which is most suitable for crop growth and this may be considered to be the optimum range. The objective of the farmer is to keep just this amount of moisture in the soil, neither more nor less. This range varies from soil to soil and its upper limit is the field capacity of the soil for moisture, that is, the quantity of water held by a moisture saturated field after the surplus rains drain to the lower layers; and the lower limit is above the wilting point, that is, when plants wilt due to dearth of moisture in the soil. At the upper limit, air and moisture may occupy about equal volumes in a clayey soil and a half of this moisture may be available for the use of crops.

Apart from the optimum moisture content of the soil being the most conducive to vigorous plant growth, it also happens to be the most economic. When more water is supplied, the excess water percolates down to the lower layers and is not utilised for the production of crops. On the other hand, it may reduce the air in the soil and

retard crop growth. Thus heavy irrigation may increase the expenditure, curtail production and reduce the profits obtainable from the crop. When smaller quantities of water alone are applied, crop growth and production are affected adversely and this again reduces the profits.

Importance of water to plants. Growing plants contain about 90 per cent of water, which gives them turgidity and keeps them erect. There is continuous evaporation of moisture from the leaves and tender parts of plants, or transpiration, which the plants make good by absorbing water from the soil. Further, the moisture in the plant is of great assistance in regulating its temperature. When the sun is severe, transpiration increases and effectively prevents the rise of temperature in the plant system. This is of particular significance in the tropics, where the prevailing temperature is high and the plants receive considerable insolation. Finally, the soil moisture has plant nutrients dissolved in it, which is utilised by plants for their growth. Thus, water is necessary for (1) providing moisture which constitutes the plant material, (2) meeting the transpiration requirements, (3) regulating the temperature of the plant system and (4) serving as the medium for dissolving and making available the nutrients present in the soil for the use of plants, and thus meeting the various physiological requirements of plants. When plants are supplied with sufficient water, there is improvement in growth and final production. Under intensive cultivation, irrigation is capable of increasing the yield of crops by 50 per cent or more, depending on circumstances.

Irrigation sources in South India. The important sources of irrigation in South India are the river, tank and well irrigation systems, which have been well developed. The

early Hindu rulers of the country developed tank irrigation systems largely and no tanks have been constructed in recent times. The British administration developed river irrigation systems by constructing *anicuts* or barrages and dams across rivers. The large irrigation systems like the Godavari, the Krishna and the Cauvery are instances. The Madras State has about 44 lakhs acres under irrigation and Andhra State has 46 lakhs acres and these represent 29.4 per cent of the cultivated area in each State. The extent of land irrigated by the various sytems in Madras and Andhra States is given below, together with the extent of the important groups of crops under irrigation :

Particulars.	Madras		Andhra	
	Area irrigated		Area irrigated	
	Lakhs of acres	As per-centage of total irri-gated area	Lakhs of acres	As per-centage of total irri-gated area
	1. From Irrigation Sources.			
Rivers	17·33	39·5	27·44	59·8
Tanks	15·27	34·8	12·66	27·6
Wells	10·55	24·1	3·92	7·8
Others	0·69	1·6	1·84	4·8
	2. Groups of Crops Irrigated.			
Rice	37·53	67·5	38·34	76·0
Miscellaneous food crops	13·97	25.2	9·80	19·4
Non-food crops	4·06	7·3	2·32	4·6
Total crops	55·56	100·00	50·46	100·00

Source : Season and Crop Report of the Madras State for the year 1952—'53, published by the Madras Government, 1955.

It is significant that irrigation is devoted primarily to the production of food crops, more particularly of rice in South Indian farming. The pressure of population on the available land is great and a large part of the irrigation is hence utilised for the production of food crops.

Transmission of water. Water used for the irrigation of crops is transmitted from the source of supply to fields through channels. These are made with soil or with masonry work. The earthen channels absorb considerable quantities of water during transmission and the quantity of water reaching the field for irrigation finally is consequently reduced. Loss of water due to absorption by soil during transmission is called 'seepage loss.' Some water also percolates down to the lower layers of soil along the course of the channels. The water so lost by percolation does not become available for irrigation. The seepage and percolation losses are variable and depend primarily upon the type of the soil, and the length, slope and condition of channels. In light soils, loss of water by seepage and percolation is considerable, while it is much less in stiff clayey soils and it increases with the length and the section of the conducting channels. Larger channels are required for transmitting water over level land than on sloping ones. The larger section of the channel increases the losses. In sloping land, water flows freely without stagnation and the loss is less. Silting up and growth of grasses in earthen channels impede the flow of water and increase the losses. So, earthen channels have to be cleaned up periodically.

In spite of the drawbacks associated with earthen channels, they are commonly preferred, as they can be made at little cost. The main channels of a permanent

nature, leading from the well to the field, are planted with coconuts on the sides and the seepage is thus beneficially utilised.

Methods of applying water. Fields are irrigated, by applying water on the surface of the soil, under the soil by laying porous pipe systems in sub-soil irrigation, or by spraying water with a regular pipe system, under pressure in overhead irrigation. The application of water on the surface is the most common method and it is called 'surface irrigation'. It is done in many ways, by (1) flood irrigation, (2) bed irrigation, (3) furrow irrigation, (4) trench irrigation and (5) basin irrigation.

1. *Flood irrigation.* Water is delivered at one point and allowed to spread over the field slowly, without scouring the surface. This is sometimes called 'wild flooding'. Swamp rice crops are irrigated by flooding and water is kept stagnating in the field. Sugarcane, banana and turmeric grown in wet lands may also be flood irrigated and the surplus water drained off later. The surface of the field does not require any preparation other than levelling and labour required for distributing water for the crops is very little. But it requires the use of large quantities of water and this is not so apparent, as water is drawn from tank and river systems.

2. *Bed irrigation.* This is the common method adopted when water is lifted for irrigation from wells. Water supply is limited in wells and not copious as from tanks and rivers. The fields are, therefore, divided into a number of small beds with temporary bunds, providing an irrigation channel for every two rows of beds, from which water can be distributed on either side. The beds are marked by running a plough along and across the

fields at suitable distances, and bunds are formed by the side of the plough furrows with spades. The bunds can also be put up with bund-formers. The beds are made small when water is lifted with *mhotes*, to enable the small flow of water to spread evenly over the beds. Larger beds are formed when water is lifted with pump sets. The bed system of irrigation economises water more than the flooding system, but laying out the fields into beds is more expensive and more labour is required for guiding water to the beds individually.

3. *Furrow irrigation.* The fields are laid out into a series of ridges and furrows, and water is allowed to flow slowly through these furrows. The basal part of the furrows is wetted by the flowing water and the inter-furrow space or the ridge is moistened by the capillary movement of water. When the inter-furrow spaces are wide, they are not completely moistened, though the crops planted by the side of the furrows get enough moisture. Furrow irrigation is particularly suitable for wide spaced crops like cotton, tobacco, chilli etc., and there is some economy of water.

Wide and deep furrows are opened for crops like sugarcane which require heavy irrigation. Shallow furrows are suitable for crops like cotton which require light irrigation. Channels are formed 10 to 30 feet apart across the furrows, for supplying them with water. They may have to be provided at short distances for sloping land and further apart for level fields.

Furrow irrigation economises water, as the inter-furrow spaces are not completely moistened, particularly when the furrows are wide apart. Evaporation of water from the soil surface is more or less limited to the base of

the furrows. The entire soil surface is not hardened by wetting at the time of irrigation. This system enables crops being planted in lines and intercultivated with animal power. The furrows serve as drainage channels during wet weather and stagnation of water in the field is avoided thereby.

4. *Trench irrigation.* Banana is planted 6 to 8 feet apart in wet lands and trenches 2 feet wide and 1½ feet deep are opened in between the banana rows and the soil removed from the trenches is used for banking up the banana plants. Water is let into the trenches and allowed to seep into the raised beds. The trenches are used for draining the surplus water collecting in the fields from the rice lands round about and drainage is more important than irrigation, here.

5. *Basin irrigation.* In young orchards, small basins are formed round the individual plants and water is let into the basins from feeder channels. This system economises water and is particularly valuable for young plantations which require irrigation at frequent intervals.

Effect of irrigation on crops. Irrigation supplements rainfall in providing moisture to the soil and in maintaining the steady growth of crops. This assists in improving the number and size of the grains on the ear heads and also the final yield. The grains produced are uniform in size and development On the other hand, the grains in rain fed crops vary in size and development, caused by variations in the level of moisture in the soil during the formation and development of the grains. There is sufficient moisture in the soil immediately after rains. When this is used up and there are not any subsequent rains, the moisture content of the soil is lowered and the

plants are not able to make steady growth. The ear heads are produced at different times and only those, which have at the time of development a favourable supply of moisture in the soil, mature properly and give perfect grains. Those that develop at other times are affected adversely, being small sized and improperly filled. Thus, the final produce has seeds of different sizes and development mixed together. All the ear heads in irrigated crops mature properly, whether they are early or late, as the supply of moisture in the soil is always maintained at the required level by irrigation.

Irrigation tends to prolong the growing period of crops and to delay their maturity, in a general way. Withholding irrigation hastens the maturity of crops. Stagnant water cuts the supply of air in the soil and the standing crops are not able to make growth. It also tends to mature certain crops before time, as with grown-up sugarcane. Stagnation of water and drought are thus alike in hastening maturity. When adverse conditions set in, caused by shortage of moisture, air or food in the soil, the plants tend to mature quickly, in their natural urge to reproduce and perpetuate the species.

Irrigation also affects the quality of the produce with regard to flavour, taste, palatability and storage life of fruits and vegetables. Brackish water affects the quality of certain crops like sugarcane and tobacco; with sugarcane, the jaggery does not set properly, while in the case of tobacco, the burning quality and flavour of the leaf are improved.

Effect of irrigation on soils. Irrigation increases the stock of moisture in the soil, which speeds up the decomposition of organic matter, the formation of humus and the various chemical reactions taking place in the soil. Conse-

quently, more plant food is made available for the use of crops at a rapid rate. Thus, when crops are irrigated without the addition of manures, the increased yield obtained is due not only to the larger amounts of moisture absorbed by crops, but also to increased chemical activity and the larger quantities of plant food released from the soil.

Irrigation helps to dissolve soluble salts formed in the soil and leach them with the drainage and to reduce their concentration in the root zone of crops, thus enabling them to grow normally in saline soils. When calcium and magnesium salts are present in irrigation water lifted from underground wells, they tone down the alkaline condition of soils to an extent. When irrigation is from muddy rivers, considerable silt is deposited over the land and it adds to the fertility of the land. The productivity of the Nile Valley in Egypt owes a great deal to the rich silt deposited by the Nile River.

Irrigation can also bring about certain adverse effects on the soil. When water is applied liberally and drainage is impeded, there is a gradual rise of water table, which promotes capillary rise of moisture and its evaporation from the surface of the soil. Soluble salts from the lower layers are brought up with the moisture and left on the surface, when there is evaporation later. The concentration of soluble salts on the surface soil leads to alkalinity. Large areas of cultivated land have thus been rendered alkaline by injudicious irrigation in Sind and Punjab.

Salts in irrigation water. Water used for irrigation from wells contains in certain cases large quantities of soluble salts, particularly in arid regions, which make it unsuitable for irrigation. Water containing less than 60 parts of soluble salts per 100,000 parts is safe for irrigation,

while anything over 150 parts may be deemed unsafe, though water containing up to 500 parts of soluble salts is sometimes used for irrigation. A preponderance of sodium over a sixth of the soluble salts is likely to affect the soil adversely.

Factors affecting the quantity of water used for irrigation. Of the several factors influencing the total quantity of water used for irrigation, the crop, the climate and the soil are the most important.

1. The crop. The water requirements of different crops and even different varieties of the same crop are very variable, depending upon the nature of the foliage, the habit of the plant, hardiness and adaptability of the plant system, the physiological make-up of the plant and so forth. Some crops use water lavishly, some sparingly and others are somewhere midway between the two extremes. Rice requires large quantities of water for its growth and sorghum can do with little water, while sugarcane, tobacco and others require fair quantities of water. Long duration varieties require more water than short duration ones of the same crop. Plants with broad leaves transpire more water than narrow leaved ones.

The quantity of water required by crops at the different stages of growth is also variable. There is in all plants a small critical period of very active growth, when their requirements are great. If sufficient water is not then provided, they receive a set-back and remain stunted ever after. There is the period of flower formation and the development of the grains, when again water is required liberally; otherwise the yield of grain is affected adversely.

2. The climate. Climate influences the water requirements of crops very greatly. Rain, wind, humidity of the

atmosphere and the prevailing temperature are the chief elements that exert this influence. Crops grown in summer require liberal irrigation, due to the great evaporation and transpiration that take place during this period. The same crops are grown with much less water during the rainy season, when the prevailing high humidity of the atmosphere and low temperature keep down evaporation and transpiration. Climate is beyond the control of farmers, but a knowledge of how climate affects irrigation requirements is of assistance in framing suitable cultural schedules. High temperature, winds and low humidity increase irrigation requirements, while lower temperature, rains and high humidity reduce the requirements.

3. *The soil.* Though the capacity to hold water may vary with soils individually, it may be said in general that light soils hold small quantities of water only, which is rapidly used by crops. If water is applied in excess of the soil's capacity, it percolates down to the lower layers, without becoming useful to crops. These soils are, therefore, irrigated sparingly at frequent intervals. Frequent irrigation involves considerable evaporation from the surface of the soil, which is inevitable. Heavy soils hold large quantities of water in a general way, because of their favourable texture and great depth, and they may be irrigated at wide intervals. The moisture is held by the soil and not lost by percolation. Since irrigation of heavy soils is at wide intervals, evaporation losses from a wet surface are reduced correspondingly.

The availability of plant nutrients in the soil has an influence on the water requirements of crops, that is, the ratio of water used by crops to the dry matter produced. This is more in poor than in fertile, or manured soils. Fertility and manuring lead to economy in the utilisation

of water. But, it must be remembered that though manuring may reduce the ratio of water used to the dry matter produced, it leads at the same time to increased production and may thus increase the total quantity of water consumed by unit area of land.

Irrigation water requirements. These are expressed by farmers in terms of the interval between successive irrigations as once in 10 days or so, or as the total number of irrigations required for raising a crop. Thus, it is said that sorghum requires irrigation once a fortnight, or that it requires 5 irrigations in all. These are not definite with regard to the actual quantity of water used for irrigation and are not comparable.

Water required by crops is supplied by rainfall and irrigation together. The total water requirement of a crop is ordinarily represented as a depth of a column of water in inches, required to be applied over the land, inclusive of the depth of water supplied by rainfall. Thus, the water requirements of rice may be said to be 64·93 inches, inclusive of 12·89 inches of rainfall, as shown below. The difference between the two represents the irrigation requirements, that is, 64·93 minus 12·89 or 52·04 inches.

Water requirements of important crops. The important irrigated crops in South India are rice, sugarcane, *ragi*, sorghum and Cambodia cotton and their water requirements have been determined at some agricultural stations. The normal water requirements are determined by noting the natural rainfall and measuring the water supplied for irrigating specific areas, over a number of years and calculating the averages of the several determinations. These are not absolute figures, but only averages under a certain set of conditions, holding good for a specific

place and soil, and which may hold good for other places and soils, only in a general rough way, and which has its value, nevertheless. The water requirements of some crops determined in South India are given below:

Name of crop.	Name of station	Rainfall in crop period	Irrigation given	Total water used	Duration of crop	Average of number of
		inches	inches	inches	days	years
Ragi	Coimbatore	5·06	17·39	22·45	129	10
Sorghum	,,	6·25	13·27	19·52	99	9
Cambodia cotton	,,	17·22	11·43	28·65	212	10
Rice	,,	12·89	52·04	64·93	129	5
Sugarcane	Palur	31·27	40·02	71·29	349	2
,,	Anakapalli	38·16	38·44	76·60	337	1

In the above determinations, *ragi* required on the average 5 or 6 irrigations with 3 inches depth of water each time. Sorghum required 4 irrigations of 3 inches depth each, once a fortnight. Cambodia cotton required 4 irrigations of 3 inches depth each, in normal years and 6 or 7 irrigations in years of low rainfall. Rice is grown under swamp conditions and water is drained a fortnight before harvest and the land is allowed to dry up. It requires about half an inch of water each day up to flowering and about a quarter of an inch thereafter. Sugarcane is a long duration crop of 10 to 12 months and requires 75 inches depth of water. A part of this is supplied by rainfall and the crop may require 30 to 50 inches depth of irrigation, that is, 8 to 13 irrigations of 4 inches depth each time.

CHAPTER V

CLASSIFICATION OF CROPS

Definition of crops. A very large number of different types of plants grow wild in a state of nature. A few of them alone have been selected by man and cultivated specifically for obtaining their produce, which can be used as food, or as raw material for the manufacture of clothing, textiles, oils etc. These groups of cultivated plants are called 'crops'. The crop plants are more uniform in appearance, growth, maturity and other characteristics, than their wild parents. Heavy bearing, uniformity and/or quality of produce are the special virtues of crop plants. These have been brought about by repeated selection of the best specimens from out of the several individuals in nature and their continuous improvement over countless generations by farmers from early times and by plant breeders in recent years.

Cultivation of Crops. All operations connected with the production of crops done in the field, go by the name of 'cultivation operations'. Fields are ploughed, manures are applied to the lands, seeds are sown, weeds that spring up are removed periodically, the crops are irrigated, pests and diseases are tackled, the mature crops are harvested and the final produce is threshed and cleaned. They constitute cultivation operations, which are liable to vary widely, with the type of soil, the crops grown, the labour available, the resources of the individual farmers and peasants and so forth.

Classification of crops. The several crops under cultivation can be classified in many different ways. Botanically, they are classified with the natural order as the basis, as *gramineae, leguminoseae, malvaceae* etc. Such a classification is helpful as the several members of the same family are cultivated more or less similarly, with minor modifications to suit the needs of individual crops. It also happens that the several members of the same family are more or less liable to the incidence of the same insect pests and fungoid diseases.

Another classification that is often made is based on the similarity of the use of the produce, as grain crops, pulse crops, oil seed crops etc. The following are the important groups of crops on this basis:

1. Cereals. The word 'cereals' is derived from the Latin word '*Ceres*', which means the Goddess of tillage and corn. The cereals include the common food grains of the world. They belong to the natural order of '*gramineae*', or the family of grasses. Rice, sorghum, *ragi, cumbu, tenai,* maize, wheat, and barley are the more important common grains in this group. They are valued for their richness in starch, the energy producer, and small and variable amounts of protein, fats, minerals and vitamins.

2. Pulses. The various grams, peas and beans are included in the group of pulses and they belong to the natural order of '*leguminoseae*'. Bengalgram, redgram, blackgram, greengram and horsegram are the major pulses that are in common use in South India. Pulses are rich in protein and they are the suppliers of protein food to the majority of people in the world, who do not partake of animal food. They combine very well with cereal foods and make the latter balanced and tasty,

besides making up the deficiencies inherent in the cereals. Pulses working in association with legume bacilli fix atmospheric nitrogen and leave the land where they are grown, richer in nitrogen. Thus, they assist in building up the fertility of the soil, and the crops grown mixed with them and those that follow them on the land are benefited by the association.

3. *Oil seeds.* Certain seeds are rich in oil and when the oil content is more than 16 to 20 per cent, it can be extracted profitably with suitable machinery. The oil seed crops thrive very well in the tropics, and oils, oil seeds and oil cake move in large quantities from the tropics to the temperate countries. India exports large quantities of groundnut oil and castor oil to other countries. The other oils produced are more or less used for internal consumption. They are used for cooking, illumination and in many ways industrially. The production of soap and glycerine is one of the big industries, which uses large quantities of oil. The various oil seed crops belong to different botanical orders like *leguminoseae, euphorbiaceae, compositeae* etc.

4. *Miscellaneous food crops.* Besides cereals, crops like banana, tapioca, sweet potato etc., are good sources of starch, stored in fruits or underground tubers. They serve as vegetables and can replace cereals as subsidiary items of food to some extent. Starch is also extracted from the various tubers and used for industrial purposes like sizing for textiles, glazing for paper etc.

5. *Sugars.* Sugar is produced largely from sugarcane and beet root, the former being important in the tropics and the latter in the temperate regions. Sugar is also extracted from the sweet juice obtained by tapping

the inflorescence of the common palms like the coconut, palmyra, dates etc. The various palm juices and sugar-cane juice are concentrated and made into jaggery, *gur*, or unrefined brown sugar in India and used instead of refined white crystal sugar. Comparatively small quantities of syrup and treacle are also made from sweet sorghums and maples in America, for use in the home kitchen and the bakery.

6. *Condiments and spices.* These are used for seasoning food of various kinds, to give specific flavour, taste and piquancy, without which many foods are flat, insipid and wanting in palatability. Chilli, pepper, mustard, coriander etc., are common condiments grown all over India.

7. *Fibre crops.* Fibres are used in the manufacture of textiles of different kinds, twine, rope, cordage, mats, gunnies and several others besides. Fibres form part of the bark and can be extracted from suitable plants by retting. Sunhemp, Bimlipatam jute and Bengal jute are the important bark fibre crops in India. The most important fibre crop all over the world and India is cotton. The cotton fibres are fine, and soft and lend themselves for being made into yarn of superior quality, suitable for the production of cloth.

8. *Narcotics.* Crops in this group produce substances, which are stimulants and give a sense of comfort, well-being, pleasure and exhilaration. Tobacco and arecanut are common narcotic field crops, which are of considerable commercial importance in South India. Tea and coffee are equally important, but they are cultivated as plantation crops in hill slopes having suitable elevation and rainfall.

9. *Green manure crops.* A number of leguminous crops are cultivated as off-season crops and ploughed into the soil to serve as green manure. They fix atmospheric nitrogen and enrich the soil at very little cost and attention. Sunhemp, daincha (*Sesbania aculeata* Pers.), *S. Speciosa* Taub., indigo, wild indigo (*Tephrosia purpurea* Pers.), and *pillipesara* (*Phaseolus trilobus* Ait.) are common green manure crops in South India.

10. *Fodder crops.* Crops are not specially cultivated for the production of fodder in South India, except in limited areas. Sorghum is grown as a forage crop in the black cotton soils of South Tamil Nad and in Central Andhra Desa. A catch crop of sunhemp is taken in wet lands after the harvest of rice in Krishna and Guntur districts, for use as hay. In other cases, the various cereal straws provide the main forage for stock.

CHAPTER VI

CEREALS

VI. 1—Rice (*Oryza Sativa* Linn.)

Vernacular names: Tamil and Malayalam - nel; Telugu - vadlu; Kannada - chatta; Hindi - dhan.

Origin. Rice (paddy) is one of the crops that has been under cultivation from very early times. It is next in importance only to wheat, as a grain crop. It is the main staple food grain in Asia and of nearly half the people of the world. It has been under cultivation in India and China from very early times and may have originated in one of the two countries, or even independently in both. It has spread from India to Persia, Mesopotamia, Turkestan, Greece and other countries. It was taken up for cultivation in Europe towards the close of the 7th century, in America during the 17th century and in Australia in recent times.

Adaptation.—*1. Climate.* Rice is primarily a tropical crop, requiring a copious supply of water, high humidity and heat. Yet, in sub-tropical regions, where a mild temperature of not less than 70° F. and long days of intense sunlight prevail, as in Italy, Spain and Japan, rice yield is higher than in the tropics, due to a more favourable climate, the use of proper seed, intensive manuring and suitable rotations. In the tropics, a mean temperature of about 80° F., within the extreme limits of 65° and 105° F. appears to be favourable. Long day-

light periods, free of cloudy weather, favour the production of rice.

The duration of rice is a varietal character, which is influenced by the prevailing temperature; low temperature increases the duration and high temperature reduces it.

2. *Altitude.* Regions within 2,000 feet of sea level are extremely suitable for the cultivation of rice. It is also being grown in altitudes from 2,000 to 5,500 feet above mean sea level in Java, Madagascar, Mysore, Coorg, Malabar, Kashmir and the Nilgiris by the use of suitable acclimatised varieties.

3. *Soils.* Rice thrives in almost all types of soils. It comes up well in the clayey soils of the Godavari and Krishna deltas, in the loamy soils of the Cauvery delta, in the light soils of the Kalingaroyan channel area of Coimbatore district, where the lower layers are gravelly, and also in coastal light sandy soils. Heavy soils are rich and produce good crops of rice, without much manuring, as in the Godavari delta. Rice may be said to prefer a a heavy soil from this point of view. The loamy and sandy soils are poor comparatively, but they respond very well to liberal manuring.

Rice is grown in soils that range in pH from about 5.0 to 8.5. Heavy yields are obtained from light acid soils rather than from neutral or alkaline soils. Very acid and alkaline soils are tolerated by some coarse varieties only.

4. *Water supply.* Rice is essentially a crop of the swamp soil, with water standing on the surface to a depth of 2 to 4 inches. It comes up well also as a purely rain fed crop, under heavy rainfall conditions, as in

Malabar. It can be raised as a rain fed crop under conditions of medium rainfall, when the rains are evenly distributed over the growing period as in the uplands along the Northern Circars coast and parts of Chingleput and Ramanathapuram districts, but the yield is low, being only a fifth or sixth of the irrigated crop. The crop requires 0·25 inch depth of water daily during puddling and from flowering to harvest, and 0·5 inch daily from transplanting to flowering, under South Indian conditions.

All these environmental conditions affect the productivity of rice. The several factors do not act independently and have therefore to be correlated together suitably, for obtaining the maximum yield possible.

World acreage and distribution. The world extent of rice cultivation and the production of paddy during the year 1952 are furnished in the statement in p. 80.

The world area under rice was 237·48 million acres during the year 1952 and the total production of paddy (grain with husk) during the period was 158·1 million long tons of 2,240 lb. each. Asia accounted for 92 per cent of the world acreage and production of paddy.

International trade in rice. Though the extent and production of rice are considerable, the quantity of rice entering international trade is limited, as the bulk of the produce in the several countries is consumed locally. The three countries which contributed about 70 per cent of the pre-war world trade were Burma, Thailand and Indo-China, where the production was in excess of the local requirements. The second world war upset the

Rice: Regional area and production, 1952.

Name of region	Area in 1,000s of acres	Production of paddy in 1,000s of tons of 2,240 lb. each
North America	2,951	2,790
U. S. A.	1,972	2,172
Mexico	203	135
Others	776	483
Europe	891	1,634
Italy	445	938
Spain	159	324
Others	289	373
Asia	219,225	145,500
Burma	9,883	6,189
Ceylon	1,000	313
China	46,470	46,270
India	74,000	34,600
Indonesia	16,500	10,270
Japan	7,850	12,140
Indo-China	12,700	5,626
Pakistan	23,015	12,250
Phillipines	6,057	2,990
Thailand	12,500	6,430
Malaya	800	670
Others	8,450	8,245
South America	6,275	4,215
Brazil	4,900	2,902
Others	1,375	1,312
Africa	7,577	3,360
Egypt	388	500
Madagascar (for 1951)	1,668	1,006
Others	5,521	1,860
Oceania	105	117
Australia	34	72
Fiji (for the year 1949)	29	25
Others	42	22
World total		158,100

Source: Based on *U. S. D. A. Agrl. Statistics, 1953—'54.*

production of rice in these countries and dislocated trade. The estimated production and export of rice of these countries are given below, for the pre-war years and 1953.

The production and export of rice have not yet come to pre-war levels in Burma and Indo-China. Thailand has increased her production by nearly 75 per cent during the period and has recovered her pre-war export level. Korea and Formosa were the other two exporting countries in Asia. Korea exported about a million tons of milled rice, chiefly to Japan during the pre-war years. Her export is now about 6,59,500 tons. Export of rice from Formosa is estimated at 1,67,300 tons, at present. Undivided India was importing about 2 million tons of milled rice during the pre-war years. The Indian Union stepped up the production of rice in recent years and exported a small quantity of rice during 1953. She is the second largest producer of rice in the world, coming after China.

Important exporting countries in other continents are the United States of America, the South American

Name of country	Estimated production of paddy in 1,000 long tons.		Estimated exports of milled rice in 1,000 long tons.	
	1937—'40 (pre war)	1953	1937—'40 (pre-war)	1953
Burma	6,841	5,706	3,021	961
Thailand	4,133	7,578	1,316	1,320
Indo-China	6,446	4,532*	1,414	212

Source: *'The world rice situation - an outline survey'*, World Crops, Sep. 1954, pp. 356, *with metric tons converted to long tons.*

Note: *(1) 100 parts of paddy is the equivalent of 70 parts of milled rice. (2)* Figures of production in Indo-China for 1953 are not available and the figure given pertains to the year 1952.*

countries, notably Brazil, Italy and Australia. They exported 7,38,200 tons, 2,56,000 tons, 2,26,300 tons and 21,650 tons of milled rice respectively during the year 1952. In the United States, the southern States alone are important rice producing countries, particularly California, Florida and Texas. Besides, rice is an important summer crop in south European countries, such as Spain, Portugal, Bulgaria, Yugoslavia and Greece, and particularly after the second world war. It has assumed some importance in Southern France and Hungary in recent years. Central American States, particularly Mexico, produce fair quantities of rice, but all the rice produced is consumed locally. In Africa, Egypt and Madagascar are the largest producers of rice.

The estimated acreage and production of paddy in the several Indian States during the year 1953-'54 are as follows :

Name of State	Rice extent in 1,000s of acres	Production of paddy in 1,000s of tons
1. Andhra	4,500	2,135
2. Assam	4,180	1,633
3. Bihar	13,016	4,202
4. Bombay	3,197	1,301
5. Hyderabad	1,743	581
6. Madras	6,378	2,975
7. Madhya Pradesh	9,065	2,663
8. Mysore	857	436
9. Orissa	9,786	2,340
10. Punjab	579	234
11. Travancore-Cochin	800	273
12. Uttar Pradesh	9,003	2,246
13. West Bengal	10,547	5,224
14. Other States	2,995	836
Total (India)	76,646	27,079

Source : '*Agrl. situation in India*', Apr. 1924, pp. 25 & 26.

Bihar, West Bengal, Orissa, Madhya Pradesh and Uttar Pradesh lead in acreage, followed by Madras, Andhra and Assam with fair areas, while other states have small areas only under the crop.

The normal extent of rice cultivation in the several districts in Madras and Andhra States are as follows:

District	Extent in acres	District	Extent in acres
Chingleput	522,720	Srikakulam }	795,930
South Arcot	526,390	Visakhapatnam }	
North Arcot	376,190	East Godavari	703,970
Salem	183,870	West Godavari	794,470
Coimbatore	132,250	Krishna	679,120
Tiruchirapalli	425,400	Guntur	467,750
Tanjore	1,338,140	Kurnool	91,750
Madurai	351,100	Anantapur	120,150
Ramanathapuram	350,270	Cuddapah	106,870
Tirunelveli	327,470	Nellore	402,590
Malabar	827,530	Chittoor	184,660
South Kanara	568,320		
Nilgiris	7,130		
Total (Madras)	5,916,780	Total (Andhra)	4,382,810

It is seen that rice cultivation is very predominant where abundant irrigation facilities exist as in Tanjore and the Northern Circars districts, fed by the rivers Cauvery, Godavari and Krishna, or in heavy rainfall regions like the West coast districts of Malabar and South Kanara. The Ceded Districts are the least important as far as rice production is concerned. There is very little of rice in Coimbatore, which is a low rainfall region, lacking in major irrigation sources.

Season. A crop season may be defined as one, when a crop comes up better than at the other seasons of the year. There are two well defined seasons for rice in

South India, corresponding to the south-west and the north-east monsoon periods.

1. Northern Circars. The first crop season from June to November, is the main crop season in the Northern Circars districts. It is called the *tholakari* or *sarwa* season, which means the season of rainfall. The rice crop has a long duration during this season. The second season, late in January to April, is known as the *dalwa* or *seethakattu* (cold) season. It is the shorter season. There is a short cold weather period of 1½ to 2 months in between the two seasons, when rice does not make satisfactory growth and is subject to severe damage by stem borers. It is, therefore, planted late in January in the Western delta and early in January in the Eastern delta in Godavari. The canals in the Godavari and Krishna irrigation systems are closed for the clearance of silt and annual repairs in April. As irrigation is available for a limited period during this season, a short duration rice crop alone can be raised successfully, and its yield tends to be low. Consequently, farmers prefer to raise a medium duration variety, like 'Garikasannavari' or 'Dalwa sannam', which gives a higher yield. This crop does not get sufficient irrigation during the period of maturity of the grains, in years of scarcity of water in the irrigation system, and suffers.

2. Tamil Nad. The first crop season in Tamil Nad goes by the name of *kar* or *kuruvai,* with a short duration of about 3½ months extending from June to September. The second one known as *pishanam* or *thaladi,* with a long duration of 5 to 6 months extending from September to March. This is also the season for *samba* rice in single crop wet lands in Tirunelveli. The corresponding single

crop season in Tanjore is from July-August to January. There is also a third season, known as *manavari,* from December to Febuary-March, when a short duration crop of 110 to 120 days is usually raised and this is confined mainly to rain fed tank areas.

The first crop, short in duration in Tamil Nad and long in Andhra Desa, gives a larger yield than the second crop which is long in duration in Tamil Nad and short in Andhra Desa. It would, therefore, appear that the season has a greater influence on yield than even the duration of the crop, though within the same season the duration markedly influences the yield, that is, when varieties with different durations are grown in the same season.

3. Central districts. There are 3 seasons in the Central districts, namely (a) *kar* or *sornavari* from June to September, (b) *samba* from September to January and (c) *navarai* from February to May, depending upon the time of receipt of water in the irrigation system.

Three crops of rice are raised during the year, one after another, in favourable localities, where irrigation is available almost throughout the year, as in parts of Tirunelveli, Malabar and South Kanara districts. Single, double and treble crop rice lands are 3,917,100 acres, 451,880 acres and 11,940 acres in Andhra Desa and 4,535,060 acres, 1,448,700 acres and 116,540 acres respectively in Tamil Nad.

Varieties. A large number of varieties of rice are under cultivation. The museum at Calcutta has a collection of over 5,000 varieties. The various conditions of soil, climate and rainfall under which rice is grown and the

long time it has been under cultivation, have given rise to such a large number of varieties. Each locality has its own popular varieties suited to the particular environmental conditions prevailing. Botanical classification of varieties is based on the characters of plants, like height, tillering capacity, leaf dimensions, ear head characters, duration of flowering, size, shape and colour of grains, pigmentation of the different parts of the plants and so forth. Farmers classify varieties in the following ways and most varietal names indicate their special characteristics.

Varietal nomenclature based on characters.

1. *Colour:* 'Karun Kuruvai' - black and short durationed; 'Sen Nel' - red coloured paddy.
2. *Size and shape of grain:* 'Gundu Samba' - round grain; 'Chinna Samba' - small grain; 'Milagu Samba' - grains rounded like pepper.
3. *Season:* 'Karthigai Samba' - one that can be planted late, even in the month of *Karthigai* (November-December).
4. *Flavour:* 'Kasthuri Samba' - musk scented; 'Punugu Samba' - civet scented.
5. *Duration:* 'Arupatham Kodai' - sixty days' summer variety; 'Avasara Samba' - maturing hastily.
6. *Locality:* 'Gobi Kar' or short duration variety of Gobichettipalayam, and
7. *Habit:* 'Kalar Samba' - withstanding alkalinity; 'Kolai Vazhai' - bunched ears with stout stalks like those of banana; 'Madu muzhunghi' -

capable of withstanding submersion in water, that is, a deep water rice.

Special varieties. Besides the varieties in general cultivation and every day use as food, there are a few varieties valued for their special qualities like size, flavour etc., and they are under stray cultivation. 'Basumathi', 'Rascadam', 'Rasanam' and 'Scented Jeeraga Samba' have fine grains and a pronounced flavour or sweet scent, and they are in particular demand for making special rice preparations like 'Briyani', which is cooked with mutton or a variety of vegetables and highly seasoned with condiments and spices. These are consumed as such or taken with sauce like 'Kurma'. Rice with very fine grain is called 'Table rice' and is preferred in occidental countries. It may be scented or non-scented. 'Non-scented 'Jeeraga Samba' is a plain table rice without any flavour or scent and it resembles 'Scented Jeeraga Samba' otherwise. Glutinous rice is a special rice with a glutinous consistency like wheat and it is steamed and consumed with coconut scrapings and jaggery. The grains do not get massed together even under prolonged cooking and the cooked rice has a certain renitency, and is not soft and yielding to the bite so readily as other rices. A part of the starch in the grain is in a modified form, which has the consistency of wheat gluten (glutin) and some of its properties.

Rotations. The cultivation of rice is specialised and different from that of other crops. It is grown mostly under swamp conditions in wet lands and it is not possible to grow other crops, side by side. Rice follows rice as a pure crop, without being rotated with other crops in wet lands ordinarily. In high level wet lands, however, rice is

grown in rotation with crops like sugarcane, banana, turmeric etc. Sugarcane is grown once in 3 or 4 years in Godavari and rice in the intervening periods. A mixture of *ragi* (*Eleusine coracana*) and groundnut is grown in rotation with rice in South Arcot district. In single crop lands, rice is followed by greengram, blackgram and *pillipesara* (*Phaseolus trilobus*) in Godavari, by a green manure or fodder crop in Krishna and Guntur, by Bengalgram in the Ceded Districts and by gingelly, onion or *ragi* in parts of Godavari and Visakhapatnam districts. Turmeric is rotated with rice in parts of Guntur, Godavari, Nandyal, Coimbatore and Tanjore. The following are some of the rotations adopted at Coimbatore:

1. Rice (2 years); betel vine (3 years).
2. Sugarcane (1 year); banana (3 years); rice (2 years).
3. Sugarcane (1 year); banana (3years); rice (1 year) and
4. Sugarcane (1 year); rice (2 or 3 years).

Rice is grown in rotation with many crops in Malabar, particularly in *modan* lands, that is, high level lands, as shown below:

1st year: Rice followed by horsegram.

2nd year: *Samai* (*Panicum miliare*), or *ragi*,

3rd year: Ginger and root crops, and

4th year: chilli.

'Budama' rice is rotated with chilli, tobacco and sunhemp for fodder in the Circars. In parts of Coimbatore, Tiruchirapalli, Tirunelveli and Tanjore, where loamy soils predominate, groundnut is sown in April with pre-monsoon showers and harvested in August. The

groundnut haulms are trampled in as green manure for the succeeding rice crop. Groundnut serves as a dual pod and green manure crop, which can be commended for adoption in other suitable places.

'Masi-pattam' Cambodia cotton is sown in February-March after the harvest of rice in parts of Tanjore, Tirunelveli and Ramanathapuram. A mixed crop of sorghum, redgram and lablab is sown in April in Tenkasi taluk of the Tirunelveli district and followed by rice in the main season.

The specific rotations referred to are confined to particular areas, fitting in well with the environment and the farmer's economy, and need not be equally suitable for other places. This does not, however, rule out the adoption of new and other agricultural practices. Some of the above rotations were developed in recent years only and have been established now as regular practices. For instance, summer cultivation of groundnut at Coimbatore and Tiruchirapalli, and of Cambodia cotton in Tanjore, Tirunelveli and Ramanathapuram are of very recent origin.

Mixtures. Rice is grown as a pure crop only, in wet lands. It is sown in dry lands as a mixture with *samai*, gingelly, redgram, cotton etc. In the uplands of Godavari, 'Budama' rice (30 lb.) and cotton seed (¾ lb.) are mixed and broadcasted over each acre of land and later redgram is sown in plough furrows 6 to 8 feet apart, at the time of covering seeds. The gram seeds are dropped in furrows by persons following ploughs in a regulated manner. The seeds get covered when the next furrow is opened. This is a common method of sowing subsidiary crops in lines mixed with other crops. This deposits the seeds at a

greater depth than drilling or broadcasting and is particularly suitable for large seeds. Rice is harvested in October, redgram in February and cotton pickings commence thereafter.

Systems of cultivation. There are 3 main types of rice cultivation, namely (1) dry cultivation, (2) semi-dry cultivation and (3) wet cultivation.

1. Dry cultivation. Rice is grown as a purely rainfed crop, where the rainfall is adequate and properly distributed during the crop season, as in Malabar, South Kanara, parts of Northern Circars and in small pockets here and there in some of the other districts. The land is ploughed with the help of summer showers and brought to suitable tilth by ploughing. Cattle manure is applied to the extent available and ploughed in. Sheep are also penned in certain tracts at about 1,500 sheep per acre for a night. Rice is broadcasted at varying rates, from 60 to 100 lb. per acre, with pre-monsoon showers in Malabar and on receipt of soaking rains during the S. W. monsoon period in other places and covered by working light ploughs and levelling boards. When the moisture is at the marginal level and not quite sufficient for ensuring proper germination, the surface soil is compacted by working levelling boards, with the drivers standing over them for increasing the weight. By this, the seeds are brought into more intimate contact with a larger number of slightly moist soil particles and individual seeds are thus enabled to have a little more moisture. This is of some assistance in promoting germination. In certain places, sheep are made to walk over the field after covering rice seeds with the same object. This is called '*Molai kedai*', that is, penning sheep for promoting germi-

nation. One hundred sheep walking over an acre for 1½ to 2 hours bring about the necessary compaction; more may be harmful. The seeds are drilled in Andhra Desa and Chingleput district, at 50 to 70 lb. per acre and covered by working blade harrows. The blade harrows are worked repeatedly within 36 hours of sowing, with the blade slightly turned upward, for compacting the soil, when necessary. This is called 'paisal padam'. In Palghat area, rice is sown in plough furrows. This is of assistance in ensuring germination, when the moisture in the soil is a little below the optimum for normal germination, at the time of sowing. The soil particles at the bottom of the furrows are not exposed to the atmosphere and dessication, and the seeds are enabled to absorb sufficient moisture and germinate.

A primitive type of shifting cultivation called *'punam'* cultivation in Malabar, *'kumri'* in South Kanara and *'podu'* in the Circars, is being done in scrub jungles, on a small scale. The shrubs and bushes are cut and burnt. The land is ploughed with pre-monsoon showers and rice is sown as a pure crop or mixed with others, inclusive of vegetables. The land is abandoned after the harvest of rice and allowed to regenerate by itself and recoup its fertility. Fresh jungle land is broken up for cultivation every year.

A type of temporary cultivation, called *'modan'* cultivation, is in vogue in the hill slopes of Malabar, where rice is sown with the south-west monsoon rains. It is followed by gingelly in the north-east monsoon season and by *samai* in the second year. The land is then left fallow for 2 or 3 years for recouping, before rice is sown again.

2. *Semi-dry cultivation.* This system of cultivation is in vogue in certain tank fed wet lands. The land is prepared, manured and sown as under dry cultivation, ordinarily as a pure crop, except in parts of Coimbatore district, where short duration vegetables are mixed with it. The sowing is done with the first soaking rains, when the monsoon sets in and the young crop is treated as a dry crop, till water is received in the supply tanks 6 to 8 weeks after sowing. It is then irrigated and treated as a swamp crop, with water stagnating in the field, till it is harvested.

The semi-dry crops depend on the moisture in the soil and rains in the early stages. The young plants of the semi-dry varieties, in common with young plants in general, are hardy and make slow growth in the beginning. They even stop growing and manage to keep alive under conditions of drought. There are special varieties, which are able to adjust themselves to restricted supplies of moisture in the early stages like 'Vadan Samba', 'Kaligan Samba', 'Kuruvakalayan' etc. After irrigation is provided, they commence vigorous growth and require plenty of water thereafter like the regular wet crops.

Where semi-dry cultivation of rice is in vogue, the water supply in the tanks is available for a limited period only and if wet cultivation is to be commenced after receipt of water in the tanks, the duration of the crop has to be limited to the period of supply of water in tanks. The cultivation of short duration varieties alone will then be possible. These are generally coarse and give low yields. Semi-dry cultivation is, therefore, a device for cultivating long duration varieties of rice under tanks, which receive supplies of water for a limited time

alone. Secondly, the time of supply of water to tanks is uncertain; it may be early or late. If it is delayed transplanting cannot be done in the proper season and the yields will be lowered. If dry sowing is adopted instead, the crop is established in the proper season, though even here timely receipt of soaking rains for effecting sowings may be a limiting factor. But, rains required for facilitating sowing are not so uncertain, as heavy and continuous rains needed for filling up the tanks with water. By adopting semi-dry cultivation, rice is started at the proper season and normal yields are secured. Thirdly, semi-dry cultivation economises irrigation water indirectly. The rice crop is not irrigated in the young stages, even when tanks get filled with water early in the season. The water is thus conserved, for use at a later stage.

Rice seeds are sown at 100 to 150 lb. to the acre under this system of cultivation. It has been suggested that the seed rate can be reduced and some seed saved thereby. It does not appeal to the farmers and their attitude is justifiable. Sowing is done when there are some rains at the appropriate season. Rains are not always adequate at the time and when sowings are done with inadequate rains, germination is only partial. Further, rains are uncertain during the early stages of growth and when the moisture in the soil is lowered by spells of dry weather, there is considerable casualty in young seedlings. The high seed rate adopted makes allowance for possible defect in germination and wilting of young seedlings, which are common in regions where this system prevails and it assures a good stand in the crop even under adverse conditions. Further, a thick stand improves the yield and quality of the straw. Rice is

cultivated to a large extent by tenant farmers, who are entitled to the entire straw and to a share of the grain produced. Straw is a valuable produce in regions of uncertain rainfall and this serves as an inducement for them to stick to the high seed rate.

When rains are received liberally after sowing rice and during the early stages of growth, the semi-dry crops have a thick stand and are thinned by working light ploughs, when the plants are about 10 inches in height. The inter-ploughing assists in keeping down weeds and invigorating the crops.

Broadcasting and drilling semi-dry rice are common methods of sowing, which are in vogue. Rice can also be established by sowing 8 to 10 seeds in each spot or hill, at distances of 4 to 6 inches from one another, in plough furrows, opened 10 inches apart, as at Cuttack. This can be recommended as being more satisfactory than broadcasting, with the following advantages:

(1) There is a saving of seed, as 40 to 60 lb. of seed per acre alone are required for sowing crops on hills,

(2) the germination of seeds and the stand of the crop are uniform,

(3) these crops withstand drought better than broadcasted crops, as the seeds are laid at a greater depth, which promotes the development of the root system in a lower layer,

(4) rogue plants and off-types in crops can be easily spotted and removed, when they are sown in hills,

(5) sowing seeds in furrows 10 inches apart facilitates interculture with bullock hoes and reduces the cost of weeding, and

(6) with such wide spacing, sunhemp or daincha can be sown at about 20 lb. per acre in lines alternately with rice. The green manure can be incorporated in the soil 8 weeks after sowing, when rice is turned over to a swamp crop. Drilling rice and green manure crops in alternate lines has been found to be better than broadcasting at the Tirurkuppam rice station.

3. Wet cultivation. This is the most common system of raising rice in South India. A little water is kept standing over the field at the time of ploughing and this may be called 'wet-ploughing'. Fields are ploughed ordinarily in the dry state, with but a little moisture in the soil and it may be referred to as 'dry-ploughing' to differentiate it specifically from the special type of 'wet-ploughing' here. The term 'ploughing' refers ordinarily to 'dry-ploughing.' The object of wet-ploughing is to suspend the soil particles loosely in water and this condition of the soil is called a 'puddle' and operations like wet-ploughing, digging etc., done to bring about this condition go by the name of 'puddling'. The field is kept under swamp conditions later, by irrigating the crop frequently.

Rice fields are wet-ploughed to start with under the system of wet cultivation. If green manure crops are grown in the field, they are pulled out and kept aside, before the ploughing is taken up. The green material is spread over the field later and trampled in after the second ploughing. If the green manure crop is not thick and tall, it can be ploughed in with heavy wooden ploughs or iron ploughs. Green leaves are also gathered from waste lands and forests near-by and trampled in the puddle under feet or with implements like tramplers. The fields

are kept flooded to facilitate the decomposition of the green material turned under, before the next ploughing is taken up. Four to six ploughings are given to the fields in all. Just before the final ploughing, the bunds are trimmed and plastered over with soft mud on the inner sides to make them water-tight. The fields are ploughed finally and made even with levelling boards, worked with bullocks.

The deltaic soils of Krishna district are stiff and clayey, and crack in summer. If they are wet-ploughed, work bullocks tend to sink in the loose mud. They are, therefore, dry-ploughed 2 or 3 times during the summer months, with the rains that may be received during this period. On receipt of water in the irrigation system, the lands are wet-ploughed once and rice is transplanted. The system is particularly suitable for this soil and is advantageous in many ways. (1) It prevents the land from cracking in summer. (2) Since the lands are prepared partially during summer, the preparation of the field at the time of planting is limited to one wet ploughing alone and 15 to 20 acres of land can be managed with one pair of animals, against 5 to 6 acres in other regions, where the land has to be wet-ploughed 4 to 6 times during the limited preparatory cultivation season; lesser area alone can be covered by wet ploughing, when compared to dry-ploughing. (3) The preliminary cultivation done in summer enables the land being prepared and planted with rice expeditiously at the appropriate season, on receipt of water in the channels.

A certain type of soil in Krishna and Guntur districts gets soft and loose on wetting. Dry-ploughing the soil produces a peculiar loose condition, locally known as

'gulla'. Workers sink lightly in the soft wet mud, sometimes up to the knee and transplanting rice becomes very difficult. Ploughing is, therefore, dispensed with in such soils and they are dug with spades, after letting in water and transplanted almost immediately.

Dry-ploughing of heavy soils reduces the yield of rice up to 10 per cent and more. The earlier it is done, the greater is the reduction. But still, it is being done in Godavari, Krishna and Guntur districts, as being the only feasible method of preparing wet lands economically and in time. It is, on the other hand, quite suitable for the lighter types of loamy soils; the yields are not affected adversely and even improvements in yield can be expected with certain types.

Broadcasting and transplanting. Broadcasting, that is, scattering the seeds evenly over the field, and transplanting seedlings are the two common methods of establishing the rice crop in the field. Transplanted crops give better yields than broadcasted crops. But, under certain conditions, broadcasting is the only feasible method. The time, when the monsoon sets in and rain-fed tanks get filled, is uncertain in some regions. Consequently, the time of preparation of the land and of transplantation of rice is also uncertain. For transplanting rice, nurseries have to be sown 4 to 6 weeks in advance of planting. Since the time of planting is uncertain and cannot be forecasted, nurseries cannot be sown at the appropriate time. In such cases, broadcasting is preferable to transplanting. The extra cost involved in raising nurseries and transplanting very short duration varieties or in transplanting in poor soils may not be covered by the extra yields obtainable. Again, shortage of labour in particular loca-

lities tends to delay transplanting and increase the labour costs, without a corresponding increase in yields and broadcasting is then better. When the season is late and delayed abnormally and also under adverse weather conditions, broadcasted crops fare better than transplanted ones.

While young seedlings are being lifted for transplanting, the roots get demaged to an extent, which serves to stimulate the seedlings to some extent, and to induce extra vigour, tillering and production. The seedlings are grown up at the time of transplanting and they are able to compete with the young weeds that spring up. In broadcasted fields, the crop seedlings and the weeds start together, and the more hardy weeds arrest the growth of the crops markedly. Weeding is no doubt effective, but it is laborious and increases the cost of cultivation. It is a debatable point whether weeding a broadcasted crop or raising nurseries and transplanting the seedlings is costlier; it will depend upon the conditions prevailing at the time. Further, the incidence of pests in young crops can affect their growth seriously. The pests can be controlled in small nurseries effectively, but not in large broadcasted fields. This assumes importance where the weather conditions favour the breeding of insect pests, during the early growing period of the crop.

Experience of the effects of the play of the several factors influencing broadcasting and transplanting has enabled farmers to fix one method or the other as being the more suitable for the several tracts and even for individual fields.

Broadcasting. Sprouted rice seeds are commonly used for broadcasting in puddle, though dry seeds are also used

occasionally. The seeds are soaked in water for 12 to 18 hours and kept heaped up for sprouting. The heap is covered with moist rice straw and water is sprinkled over it occasionally, to maintain the moisture. The seeds start germinating in about 24 hours and sprouts appear as small, white protuberances resembling pin-heads. At this stage, they are scattered uniformly over the field. If the sprouts are allowed to grow too long, they get broken at the time of sowing.

The particles of mud are in a stage of suspension in the fresh puddle and settle down slowly. The seeds are broadcasted after the mud settles down. Water is kept standing in the field as a buffer to a depth of about 3 inches at the time of sowing, to take up the impact of the seeds and prevent them from sinking in the mud. The water is drained from the field after sowing. When dry seeds are sown, water is kept standing in the field for about 18 hours and then drained. As the field is levelled properly before sowing, water does not stagnate over the field. When there is stagnation of water in shallow patches here and there, it is drained by forming small water ways suitably; otherwise the submerged seeds do not germinate and the stand of the crop becomes uneven. Irrigation is given every third day and the water is drained after 2 or 3 hours, so that the germinating seeds may be supplied with sufficient moisture and air.

The quantity of seeds broadcasted varies from place to place and the seed rate in common use ranges from 60 to 100 lb. to an acre. It is very high and seedlings come up thickly in the field. The crop is thinned after 5 weeks and the thinnings are used for filling up gaps in the field and for transplanting other fields.

Nurseries. Seedlings required for transplanting are raised in specially prepared nurseries, and they may be of the dry or wet type. They are raised on fertile lands, having proper irrigation and drainage facilities and the same sites are used for nurseries year after year. Their fertility is maintained at a high level by adequate manuring.

Dry nurseries. Light loamy soils with adequate drainage facilities are selected for nurseries and they are dry-ploughed in March-April, on receipt of summer showers. When rains withhold, an irrigation is given for moistening the soil and it is ploughed when it comes to condition. The nursery is ploughed repeatedly till a good tilth is obtained. Cattle manure is applied at 15 to 20 cart-loads (=7½ to 10 tons) per acre. Sheep are also penned instead, up to 2,000 sheep per acre. Farmers usually sow 7 to 10 lb. of seed in each cent and raise 10 cents of nursery for each acre to be planted. Seeds are sown with the commencement, or even in anticipation of rain sometimes and covered with light wooden ploughs. Small beds are formed, with channels in between rows of beds, to facilitate irrrigation being given, when required. If rains withhold, light irrigations are given to the nursery on the day of sowing and on the third or fourth day, and a third irrigation later, if necessary. The land is moistened sometimes and seeds are sown when it comes to condition with the moisture at the correct level. The nurseries are raised ordinarily with the prevailing rains and irrigation is resorted to, only when absoutely necessary. The nurseries are weeded once or twice.

The seedlings get ready for planting in 25 to 45 days, depending upon the duration of the variety and the rate

of growth of the seedlings in the nursery. The nursery period is roughly one week for every month of duration of the crop. Seedlings of short duration varieties, 25 days old and 8 to 10 inches high, are suitable for planting. It is not so much the age of the seedlings, as their growth, that decides their fitness for being transplanted. The seedlings have to be robust and grown up properly at the time of transplantation, as otherwise they establish slowly or fail to establish satisfactorily, being unable to stand the shock of lifting and transplanting. If the growth of the seedlings in the nursery is stimulated by suitable cultivation, manuring and adoption of a thin seed rate for sowing, they can be pulled out early and the transplanted crop will have a long period of growth in the field. The earlier the seedlings are lifted from the nursery, the higher is the yield likely to be.

When rice seedlings cannot be transplanted at the proper stage of growth and are kept over in the nursery, they form nodes. They are not quite suitable for planting. They do not make normal growth and do not tiller freely in the field. The primary tillers rush to flower early and produce small ear heads and the yield gets reduced. The aged seedlings have to be transplanted close, 4 inches apart with 2 or 3 seedlings in each hole, to compensate the tendency to low yield. It may also be partially got over by planting the seedlings deep in the soil, right up to the node. Planting over-aged seedlings may in most cases be better than raising seedlings afresh and missing the proper season.

The nursery is wetted and the soil is softened before lifting the seedlings, to reduce injury to the root system of the young seedlings. Excessive injury to the roots

leads to delay in establishment and a needless check is imposed on the growth of seedlings. If the seedlings are pulled out and there is delay in transplanting, it tells on their establishment. They can be planted safely up to 3 days after lifting; the earlier the better, particularly with short duration varieties. The seedlings are, therefore, lifted from the nurseries in stages, as the transplantation progresses.

Regulation of growth in nurseries. Rice nurseries are sown 4 to 6 weeks in advance of the time of planting, in general. It sometimes happens that water is not received in tanks at the anticipated time. The seedlings may have, therefore, to be kept in the nursery in a condition fit for planting over a longer period by regulating the growth of the seedlings. This can be done easily by regulating the supply of water to the dry nurseries. The seedlings here make growth with the moisture in the soil at the time of sowing. When subsequent rains fail and the moisture content of the soil falls down, their growth slows down initially and ceases completely later. Finally, they start wilting. A light irrigation is then given, to keep them alive and struggling, but not to induce growth or vigour. This is necessary as the failure of rains postpones the time of receipt of water in the irrigation system also. The nurseries are irrigated liberally and stimulated by the application of ammonium sulphate at $\frac{1}{2}$ to 1 lb. per cent, after the irrigation system gets a regular supply of water and 8 to 10 days before transplantation of rice. The seedlings respond, make rapid growth and get ready for planting in time. Since they are hardened by drought in the nursery, they are able to withstand drought in the main fields also, later. If the nursery growth is controlled by regulating irrigation, short duration varieties

can be kept in the nursery up to 45 days and long duration varieties up to 70 days and more. The total duration of the crop, made up of the nursery period and the life period of the crop in the transplanted field, is not much influenced by the retention of the seedlings in the nursery for a longer period. When the nursery period is prolonged, the life period of the crop in the field is reduced correspondingly, more particularly with short duration varieties, which are period-bound, in general.

The growth of seedlings in wet nurseries has also been regulated in a similar manner at the agricultural research stations at Maruteru and Coimbatore. Wet nurseries were allowed to dry up after the seedlings had made some growth and they were kept in the nursery for more than 50 days in a condition fit for planting in the case of medium duration varieties. The seedlings established quickly after transplantation, grew normally and came to flower by about a fortnight earlier than crops established by planting normal aged seedlings.

Prolonging the nursery period by controlling the growth of seedlings in the nursery with regulated irrigation can be of great practical assistance in regions, where the supply of water tends to be uncertain towards the tail end of the life of the crop and to affect the yield adversely. Nurseries can be sown earlier than the normal period by 10 to 15 days, the growth of the seedlings regulated by adjusting irrigation and the aged seedlings transplanted at the time of the normal transplantation. This will increase the nursery period and reduce the field period of crops by 10 to 15 days. The crops will then get ready for harvest earlier by the same period. Any shortage of water in the irrigation system towards

the end of the season cannot affect such crops that mature earlier.

Wet nurseries. Lands, which have facilities for irrigation and drainage are selected for raising wet nurseries and they are maintained in a fertile condition by adequate manuring. They are wet-ploughed, green leaves are applied up to 10,000 lb. per acre and the undecomposed twigs and branches are removed after the leaves decompose. Ploughings are continued till a proper puddle is produced. Long beds, 6 to 8 feet wide, are formed with channels all round and levelled with small wooden lathes. Sprouted rice seeds are sown after the loose mud settles down in the beds. Farmers sow 7 to 10 lb. of rice in each cent usually, as in the dry nurseries. Water standing over the beds is drained 12 hours after sowing. A small knob of the size of the fist is formed with straw at the end of a long bamboo pole and shallow water ways are made on the beds for draining the water collecting in shallow pools here and there. The nursery beds are irrigated on alternate days and drained after a short time. Water is kept standing in the beds up to the stem of the seedlings, after the 10th day. When rains are expected during the first 3 days of sowing, before the seedlings that emerge get anchored in the soil, water is kept standing in the beds to a depth of 2 or 3 inches, for taking up the impact of the rain drops, which would otherwise immerse the germinating seeds in the soft mud and lead to a poor stand of seedlings.

Nurseries in sandy soils. Nurseries are raised in the coastal sandy strip between Bapatla and Chirala in the Guntur district and in Gudivada of the Krishna District by small tenants in the following manner. The soils are

FIG. 11. Pudding rice fields with wooden ploughs under swamp conditions.
—*Courtesy*: *Director of Agriculture, Madras.*

FIG. 12. Trampling Green leaves in rice fields

—*Courtesy: Director of Agriculture, Madras.*

FIG. 13. Levelling rice fields with levelling boards.

—*Courtesy: Director of Agriculture, Madras.*

FIG. 14. Transplanting rice seedlings in wet rice fields.

—*Courtesy: Director of Agriculture, Madras.*

FIG. 15. Harvesting rice.

—*Courtesy: Director of Agriculture, Madras.*

FIG. 16. Hand-threshing rice sheaves.

—*Courtesy*: *Director of Agriculture, Madras.*

nearly made up of sand without any apparent trace of soil material. Cattle manure is applied up to a cart-load per cent and rice is sown thick, at 10 lb. per cent. Water is available at a depth of 5 to 8 feet from the surface and temporary step wells are dug for supplying water to the nurseries. It is lifted in pots and sprinkled over the nurseries twice a day, in the morning and in the evening. Seedlings are got ready for sale by the beginning of June, when the canals are opened for irrigation. Facilities for raising nurseries in time are lacking in the deltaic areas and hence there is a good demand for the seedlings so raised. They are taken even to distant places by boats, carts and trains. An acre of nursery supplies seedlings sufficient for transplanting 40 to 80 acres and the ultimate seed rate works to $12\frac{1}{2}$ to 25 lb. per acre of planted field. This is about the lowest seed rate adopted in South India. Rice seedlings are raised likewise, on the beds of the Nagavalli River in Visakhapatnam district.

Choice of nurseries. Wet and dry nurseries have their special advantages, one over the other and are individually suitable under certain conditions. The choice of the type depends upon the local conditions, the irrigation facilities available and the suitability of the land. Wet nurseries can be started in advance of the time of planting, when water is available in sufficient quantities for preparing the nurseries and for irrigation. Heavy soils and even alkaline soils can be used for raising wet nurseries, though they are not suitable for dry nurseries. The seedlings make rapid growth in wet nurseries. When seedlings are required within a short and limited period, as for the second crop season, wet nurseries alone are suitable. Further, the second crop is started during the north-east monsoon season,

when the land lies wet and does not lend itself for the preparation and the maintenance of dry nurseries.

Dry nurseries are particularly suitable for tank-fed areas, where the time of receipt of water in the tanks is uncertain and the seedlings may have to be kept in the nursery in a condition suitable for planting over a long period. They require a long period of preparation and are costlier when compared with wet nurseries. Dry nursery seedlings establish quickly and stand droughty conditions extremely well, later.

Transplanting. Transplantation is commenced, when the main field and the seedlings are ready for planting. The seedlings are pulled out, with the roots intact, as far as possible. They are made into small bundles, after washing the roots free of the adhering mud, and transported to the fields, mostly in head-loads. Where seedlings have to be carried over short distances along the course of small channels in the Circars region, the seedling bundles are strung over coir ropes stretched across the channels and dragged over the water course by men standing on the bunds. The seedlings are later distributed over the field and transplanted.

Seedlings are pulled out from nurseries to the extent required for planting during the day. The seedlings are arranged in circular heaps with the roots exposed and the shoots inside, in Malabar. Heat develops inside the heap, and it assists in destroying the mealy bugs and egg masses that are present. The seedlings in the heap turn pale and light yellow, and lose their turgidity to an extent. The seedling bundles are taken out after 3 days and kept in water overnight, when the seedlings regain a little turgidity. They are transplanted the next day.

Bunch Planting. Farmers use a high seed rate of 7 to 10 lb. per cent of nursery. The resulting seedlings are thin and spindly and take a long time to make growth and get fit for planting. They do not form nodes and tillers as quickly and readily, as seedlings raised in thinly sown nurseries. They can, therefore, be kept in the nursery in a condition fit for planting over a longer period. As the seedlings are thin, they cannot be pulled out from the nurseries individually, but only in bunches and they cannot be separated readily during transplantation, as their roots are inter-twined. They are, therefore, planted in bunches of 5 to 15 in each hole. This is called 'bunch planting'.

Thickly sown nurseries remain in a state fit for planting over a long period and this gives the small peasants considerable freedom, latitude and leisure for preparing the field. They do not own bullocks and depend on hired ones, which are not always available at the time required. Land has to be prepared only when bullocks are available for hiring. Further, the bunch planted crop comes up thick in the field and the straw produced is thin and pliable, and it is relished by animals. The disadvantage associated with bunch planting is that large quantities of seed have to be used for sowing.

Single Planting. The seed rate recommended by the Madras Agricultural Department is $2\frac{1}{2}$ to 3 lb. per cent of nursery. Seedlings have then individually more space in the nursery and they come up vigorously and are robust. They get ready for planting earlier than when a high seed rate is adopted. They can be pulled out from the nurseries individually, separated easily and

single seedlings can be planted in each hole. This is called 'single planting'. Since the seedlings remain in the nursery only for a short period, they have a long field period of growth, which facilitates free tillering, particularly in fertile fields. Single planting is largely in vogue in parts of Krishna and Guntur districts. It is not suitable for places, where crab damage prevails, or where the fertility of the soil is low.

Single planting requires that the seedlings should be robust and lend themselves for being separated easily from one another at the time of planting. This is possible only when the seeds are sown thinly in the nurseries and vigorous growth of seedlings is promoted. This effects a saving of seed and is its special advantage. The straw produced is rather thick and not so pliable as that produced by bunch planted seedlings.

Economic Planting. With short duration varieties and low fertility areas or alkaline soils, it is advantageous to plant 2 or 3 seedlings in each hole, 4 inches each way. Rice is planted in bunches of about 8 seedlings in each hole, 12 to 15 inches apart, in parts of the Godavari region. These may be classed as 'economic planting', and it refers to the economisation of seed material, consistent with the production of a satisfactory crop.

Economic planting with 2 or 3 seedlings in each hole is midway between single planting and bunch planting, and shares the advantages associated with both. There is saving of seed material, good tillering, high yield of grain, and improvement in the quality of the straw produced, and adaptability and suitability to rich and poor soils, in all localities.

Experiments, conducted in South India with single planting, bunch planting and economic planting, show that no single system is consistently superiorto the others in point of yield and they may be taken to be of equal value from this stand point. Planting seedlings close to one another tends to give more yield and short duration varieties can be planted 4 inches apart and long duration varieties 6 inches apart. Bunch planting gives fine quality straw. This is a consideration with farmers, particularly in regions of fodder scarcity. Rice straw is the main feed for cattle in wet land regions and concentrated feeds are not provided, except during the cultivation season. Hence, the production of quality straw assumes an importance along with the production of grain.

Seed rate. The quantity of seed used for raising rice is very variable. It is as low as 12½ lb. per acre for transplanting in parts of Krishna district and as high as 150 lb. an acre for broadcasting in tank-fed areas, where rainfall conditions are not certain. The following seed rates are recommended for general adoption. A seed rate of 3 to 4 lb. per cent of nursery both for wet and dry nurseries is suitable; a higher seed rate is not necessary. Seedlings produced are then robust and can be used for planting singly or in twos and threes. Seedlings from 7 to 10 cents of nursery, raised with 25 to 40 lb. of seed, will plant an acre, depending upon the duration of the variety and the size of the grains. Short duration varieties have to be planted close to one another and require larger areas of nursery than long duration varieties, which are planted wide apart. Broadcasted crops can be raised with 40 to 50 lb. of seed in an acre both under wet and dry cultivation and with 60 to 70 lb. under the system of semi-dry cultivation.

Time of sowing. The time of sowing broadcast crops and of transplanting has a profound influence on the behaviour and performance of the rice crop, particularly with certain varieties. They grow normally in certain seasons only and come to flower at a particular part of the year. When sown in other seasons, they are either stunted or keep on growing, till the approach of their specific flowering season. When such varieties are planted early, they have a long duration and when sown late, they have a short duration. They do best when planted at the specific time of the year appropriate to them. Such varieties are called 'season-bound' varieties, which flower only at a particular part of the year or season. Most long duration varieties are more or less season-bound. They do not germinate immediately after harvest, in general, and have to pass through a resting period of 1 to 1½ months, when the capacity to germinate is developed. Others are not season-bound, but come up normally throughout the year, and have a specific period of growth or duration. They are called 'period-bound' varieties. Most short duration varieties are period-bound and have a specific duration, irrespective of the time of sowing. They germinate immediately after harvest, and even on the ear heads when crops are lodged, without requiring a period of rest. Certain short duration varieties like 'Rasangi', 'Basumathi' etc., are an exception and require a resting period before they can germinate.

There are also cosmoplitan varieties like G.E.B. 24, which has spread over South India and has been popular steadily for over 40 years now. It is a typically season-bound variety at Coimbatore, flowering towards the end of October, when transplanted at any time from March to September. It does best when transplanted in July. It is

not so season-bound either in Tirunelveli or Madurai, where it is transplanted in November and August respectively.

Manuring. An average rice crop removes 50 lb. of nitrogen, 25 lb. of phosphoric acid and 40 lb. of potash from an acre. Rice responds uniformly and extremely well to nitrogenous manuring in South India. It absorbs nitrogen in the form of ammonia under swamp conditions, though it is not incapable of absorbing nitrate nitrogen under certain conditions. When the water supply in the irrigation system fails during the crop season and the soil gets dry, there is aeration of the soil and nitrates are formed. The nitrates are then absorbed by the standing rice crop.

South Indian soils are well supplied with potash and rice does not respond to potassic manuring.

Phosphates are also efficient generally, though not to the same extent as nitrogen. The response to phosphates is not marked or spectacular as to nitrogen. It does not mean that phosphates are not deficient or that phosphatic manuring is not necessary. The phosphates that are applied are rendered insoluble and made unavailable. This appears to be more than probable, since bone meal containing more than 40 per cent of organic matter and superphosphate applied with green leaf give marked responses.

Numerous experiments conducted in various soil types in South India indicate that

1. rice responds generously to nitrogenous manuring in a universal manner,

2. raising green manure crops on the land and ploughing them in is the most economical method of supplying nitrogen to the soil,

3. among the several nitrogenous manures, green manures, oil seed cakes and ammonium sulphate are efficient in increasing the production of rice,

4. a judicious combination of organic and inorganic manures supplying nitrogen is more effective than either the one or the other applied singly,

5. about 30 lb. of nitrogen per acre is the optimum dose for rice, in most cases in South India and

6. the response of rice to phosphatic manures is variable, depending upon soil conditions. It is pronounced when phosphates are applied with geeen manures.

Nitrogenous manuring. It may generally be said that (1) 8,000 lb. of green leaf alone, (2) 4,000 lb. of green leaf supplemented with 150 lb. of ammonium sulphate, or 400 lb. of groundnut cake, will each supply 30 lb. of nitrogen per acre and meet the manurial requirements of rice in South India. Poor lands require more and fertile lands less. When fertile lands are manured heavily with nitrogen, there is rank growth, lodging of the crop, incidence of the 'Blast' disease and considerable drop in yield.

Farmers apply cattle manure to wet lands, usually when they are dry-ploughed and rice is proposed to be sown after the soil is moistened by rains, but not when they are puddled for the transplantation of rice. In swamp rice soils, cattle manure is not as efficient as green leaves.

Phosphatic manuring. Phosphates are also necessary for maintaining a high level of fertility and the production of rice. They can be applied at the rate of 30 lb. of phosphoric acid per acre, in conjunction with green manures.

Time of application. Green manures may be applied to rice lands 3 to 4 weeks in advance of transplanting and allowed to decompose. Phosphates may be broadcasted over the land just before the last ploughing. There are indications that applying them in plough furrows at the time of the last ploughing may be better than broadcasting. Ammonium sulphate can be applied in 2 doses, two-thirds at the time of transplanting and one-third 4 weeks after transplanting with short duration varieties and 6 weeks after in the case of long duration varieties.

Results of manuring. Since rice is the most important crop in South India, its responses to manuring have been studied at a number of agricultural stations, and by crop sampling methods in peasants' fields. These indicate that responses to nitrogen are positive and significant. One pound each of ammonium sulphate and superphosphate increases the yield of rice grain by a little over 3 lb. and 1·25 lb. respectively on the average. Fifteen pounds of green leaf increases the yield by 1 lb.

It is sometimes suggested that if rice nurseries are heavily manured, the need for manuring the main field may not be very necessary. Experiments, made at the various agricultural stations in South India to assess the value of this suggestion, have not given consistent results. There was some initial vigour in crops raised with seedlings from heavily manured nurseries, but this evened out as the crops grew up. Manuring the nurseries heavily

was not of much assistance in increasing the yield of rice. But, heavy manuring of seed-beds helps to force the seedlings and get them ready for planting early in the season.

After-cultivation. Rice requires very little of after-cultivation, and the removal of weeds is the main operation. Weeds come up in large numbers in broadcasted fields. They germinate and grow with the rice seedlings. Being hardy by nature, they suppress the growth of the latter. In transplanted fields, the rice seedlings are grown up at the time of transplantation, while the weeds are young, delicate and not so vigorous as to suppress the growth of rice markedly.

The weeds are hand picked, 3 to 4 weeks after sowing or transplanting rice in wet lands. The gaps in the field caused by the death of seedlings are sometimes filled up with fresh seedlings at the same time. If the fields are free of weeds, labourers are made to walk over the fields, for disturbing the root system lightly. This invigorates the crops and stimulates the formation of fresh tillers.

In dry lands, the rice crops are hoed like other crops and the weeds are removed. In drilled crops, blade harrows (*dantis*) and light ploughs are worked in between the rows, instead of hoeing. A number of harrows are attached to a common yoke and an equal number of rows are cultivated in each trip. The crops are also thinned, when necessary and the thinnings are used for filling up gaps, if the weather is showery at the time.

Wet rice crops and sometimes semi-dry rice make rank growth and lodge prematurely, tending to spoil the grain and reduce the yield. Such crops are topped, that

is, the plants are cut back just above or at the leaf junction. The topping has to be done early with at least an interval of one month between topping and flowering, as otherwise it interferes with flowering and reduces the yield. Common salt is applied in parts of Tirunelveli at 10 lb. per acre to keep down rank growth in rice fields.

Irrigation and drainage. Where there are facilities for irrigating rice from assured river and tank irrigation systems, rainfall and its distribution are not of much importance. Rice requires about 75 inches depth of water under wet land conditions. In deltaic areas, a continuous stream of water is kept moving from field to field from the time the young seedlings establish to about a fortnight before harvest, except for a short break during flowering. Where the supply of water is from tanks and uncertain sources, water is conserved by keeping it impounded in fields and letting in water only as and when necessary, at periodic intervals. The preliminary puddling of the land helps to make the substratum impervious to an extent and prevents percolation of unduly large quantities of water to the underground layers. The movement of water to the lower layers is not completely prevented; it takes place at a slow and reduced rate.

Rice fields are allowed to dry up after transplantation for a few days, with the object of inducing uniform growth and hardiness in the root system, in parts of Tanjore and Godavari districts. Draining water from the fields for about a fortnight at the time of flowering induces uniformity of flowering. Water is drained a week before harvest and sunhemp or *pillipesara* is intersown amidst the standing rice crop, for production

of fodder in Godavari, Krishna and Guntur districts. Similarly, blackgram or greengram is sown for grain in many districts. When water is drained from the rice fields sufficiently before harvest, the surface soil gets firm, the harvest of the crop is facilitated and the grains and the straw do not get soiled with wet mud at the time of harvest.

The quantity of water used for irrigating rice under swamp conditions was determined at the Paddy Breeding Station, Coimbatore. The quantity of water used by the crop at the different stages, inclusive of the water supplied and rains received during the period, was as follows:

1. Preparation of the field, up to flowering - 25·63″.
2. Planting to flowering - - 48·27″.
3. Flowering to last irrigation - - 10·89″.

The growth of the crop. The rice plant produces side shoots or branches, called 'tillers'. Tillering is vigorous during the early stages of growth and slows down after a time. The tillers make rapid growth and come up to the level of the main shoot in a short time. The leaf that emerges just before the appearance of the flower head is short, pointed and more or less erect. It is called the 'short' or 'shot' blade. Shortly after the flower heads emerge, there is pollination of the flowers and the grains set and develop. The grain is soft in the early stages and a white milky fluid oozes out, when it is pressed and this is refered to as the 'milky stage'. The fluid matter turns into dough in due course and this is called the 'dough stage'. The moisture in the grain is gradually lost, the dough hardens and the crop gets ready for harvest. Most

varieties of rice lodge during the final stages of ripening of the grains, due to the weight of the ear heads. Some varieties like G. E. B. 24, MTU. 3, MTU. 8 etc., have a naturally stiff straw and do not lodge normally.

Harvesting. The mature crop dries up gradually. The harvest is taken up when most grains are mature and a few grains at the base of the ears are still green, in Andhra Desa. The cut crop is dried in the field for a few days, stacked and threshed later. The grains thus produced lend themselves for being milled in a raw state without much breakage. In Tamil Nad, the crop is harvested mostly after it is dead-ripe, the produce is threshed (or thrashed) and the grain is taken home on the day of harvest itself. This is suitable for being par-boiled and is liable to heavy breakage, when milled in the raw state.

The rice plants are cut with serrate edged sickles. When the land surface is fairly firm, short stubbles alone are left in the field. The fields are slushy in deltaic regions and long stubbles are left behind, over which the cut sheaves are laid.

Threshing. Small sheaves of rice plants are held together with straw twists or ropes and struck against hard surfaces, either on the floor or on stone slabs, for separating the grain. Hand threshing separates 90 to 94 per cent of the grains in most varieties. Certain varieties do not shed the grain easily and some shed their grain almost completely. The hand threshed grains are heavy and those sticking to the straw are light and not so well developed.

The hand threshed sheaves are spread out on the threshing floor and teams of cattle of 4 to 6 strung

together side by side, are driven round and round the loose sheaves. The grains get separated completely. The straw gets supple and pliable by the treading of cattle and the layer on the surface lies loose and tangled. This is removed and treading is continued. After the removal of the entire straw, layer by layer, grain mixed with chaff and broken bits of straw is left behind. The chaff is removed by raking with fingers. The finer chaff, empty ears and sand that are admixed with the grains are separated by winnowing.

Winnowing is done, when there is steady wind. Small quantities of grain are poured down, or thrown upward with small hand winnows and allowed to drop down through some height. The grains descend vertically, when the wind carries the lighter chaff and empty grains, and lays them at the foot of the forming grain heap, on the leeward side. The chaff thus separating is swept off periodically, leaving the grain in a clean condition.

In the Circars region, labour is scarce and sufficient labour for carrying out both harvesting and threshing together is not available at the time. The produce is stacked and threshing is taken up later. The grain undergoes slight fermentation during the period and lends itself for being milled into raw rice, without much breakage. Sunhemp is sown in the fields a few days before the harvest of rice in Krishna and Guntur districts. It makes good growth with the moisture in the soil and is cut at the flowering stage, when it is 2 months old, dried and stacked with rice straw. The feeding value of the straw is considerably enhanced by the addition of sunhemp hay. The harvest of the sunhemp and the threshing of rice are done at the same time.

Just then, '*pyru galli*', the seasonal wind of the Circars sets in, which greatly aids winnowing and cleaning of the rice grain. The produce is hand threshed and later cattle threshed, or the produce is cattle threshed without any hand threshing preliminarily.

Storage. The cleaned grains are dried in the sun and kept in storage. If the grains are not dried properly, they get heated in storage and become mouldy. If they are over-dried, there is considerable breakage of rice during milling. Seed grains have, however, to be dried thoroughly, before storage.

In Guntur and parts of Krishna districts, paddy for home consumption is kept in pits for a period of about 3 months and is then transferred to the permanent store. The pits are dug in elevated places, lined with rice straw twists on the sides and the bottom, and filled with paddy by about March. A layer of rice straw is spread over it and it is finally covered with a layer of earth, 1½ to 2 feet thick. The grain is removed before the monsoon sets in, in June. The rice, produced from pitted paddy, is mellow, palatable and suitable for cooking like rice kept in storage for about 6 months, while fresh raw rice lacks good cooking quality. It, however, loses its capacity to germinate, during the period of pitting.

For seed purposes, a small area is set apart. Rogueing is done, for maintaining the purity of the variety. To avoid contamination of the seed material at the time of threshing, the selected plot is harvested in the beginning or at the end and threshed on a separate floor. The seeds have to be preserved in moisture and insect proof containers or suitable rooms. The quantity of seed material stored is ordinarily twice the quantity required

for sowing in the ensuing season, as a provision against damage to nurseries and failure of crops.

Yield. In single crop wet lands, the yield of paddy ranges from 1.000 to 3,500 lb. per acre and 1,600 lb. may be taken to be a fair average and that of straw to be 3,600 lb. In double crop lands, the yield ranges from 2,500 lb. to 5,000 lb. of paddy and 4,000 to 6,000 lb. of straw for both crops together. Under rain fed conditions, the yield ranges from 500 to 1,500 lb. of paddy per acre. The estimated standard yield of paddy is 1,447 lb. for the Andhra State and 1,353 lb. for the Madras State.

The yields of paddy in the different countries of the world are of the following ordcr :

*Mean yield of paddy in lb. per acre.**

Country	*Yield*
Italy	3,990
Australia	3,300
Japan	3,000
U. S. A.	1,840
Indonesia	1,230
Thailand	1,150
Burma	1,090
Pakistan	1,070
India	1,030
Ceylon	670

The yield of paddy in Japan and Italy are 3 to 4 times the yield in India. Though this is due to better cultivation, it may in part be also a result of the long day length in summer in these countries when rice is cultivated and to the favourable pH of the soil. This appears to

* *Source :* Based on '*World rice situation—an outline survey*'; World Crops, Sep. 1954, p. 358.

be more than probable since high yields are obtained under analogous conditions in Tirunelveli district. The first crop is raised here during the S. W. monsoon season, when the weather is clear, sunny and fairly mild, with long day light periods when compared to other seasons. The pH of the soil is in the neighbourhood of 6.5, while it is higher than 7.0 in other regions in South India. The yield of paddy ranges from 3,000 to 4,500 lb. per acre and touches even 6,500 lb. in isolated individual cases, in spite of the crop having a short duration 110 to 120 days only.

Rice products. Paddy is the entire grain produced by the rice plant. It is dehusked by hand pounding in mortar with wooden pestles and the kernel or rice is separated by winnowing. Cleaned rice was being produced mostly by hand pounding in South India, till about 30 years ago. It is now produced by hulling and polishing in rice mills. The epidermal bran and the germ in the grain are removed during polishing. The bran is rich in protein, vitamins, and mineral matter, and excessive polishing lowers the nutritive value of rice, though it makes the cooked rice more attractive. Rice bran is separated from the coarse husk by sieving and it is used for feeding cattle. It includes fair quantities of small pieces of rice husk, which reduces its value. Its ingestion in large quantities tends to set up impaction of rumen in cattle. The sieved rice husk is used as fuel for steam boilers and furnaces. A small quantity of rice is used for making popped rice and rice flakes.

The ratio of cleaned rice to paddy is 70 to 74 per cent by weight and 50 to 55 per cent by volume.

Fresh raw rice cooks to a pasty mass and tends to upset digestion. The digestive juices do not get intimately

mixed up with all the particles of rice, as a small surface alone is presented for the action of the digestive juice, and the material lies heavy in the stomach in an undigested state, for a long time. The lumping of cooked rice is believed to be associated with an enzyme present in the fresh raw rice, which gets destroyed in course of time when rice is in storage. The starch also undergoes certain changes during storage and old rice tends to swell and increase in volume during cooking more than fresh rice. If fresh raw rice is lightly roasted, it gets cooked in the normal manner, without becoming lumpy and the cooked grains are in a separated state, which are readily and easily digested. If a little gingelly or some sweet oil is added to fresh raw rice at the time of cooking, there is not much of lumpiness in the cooked rice.

Nutritive value of rice. The following statement gives the percentage composition of some common types of rice : *

Nutritive ingredients	Raw rice			Par-boiled rice		
	Separated with wooden grinder	Hand pounded	Milled	Hand pounded	Milled	Rice bran
Moisture	14·1	14·5	14·4	12·6	13·6	—
Protein	7·2	6·8	6·7	8·5	6·4	6·94
Fat	2·3	1·4	0·7	0·6	0·4	12·98
Carbohydrates	75·1	76·2	77·4	77·4	79·1	39·85
Mineral matter	1·3	1·1	0·8	0·9	0·8	6·92
Vitamin B_1 mgm. per 100 gm.	285	240	90	170	210	

* Source : Aykroyd W. R., Health Bulletin No. 23, Nutrition Research Laboratories, Coonoor, 1951, p. 28.

Rice is the staple food grain of the bulk of the people in South India. It is rich in carbohydrates and has a high energy value. It is considered to be poor, when compared to wheat, chiefly because of its lower protein content. But, rice protein is biologically more valuable than wheat protein; rice and wheat have biological values of 86 and 67 respectively. The peripheral layer of the rice grain, called 'bran', is rich in minerals, protein and vitamin B_1, which are lost to a considerable extent during milling and the washing of the grain before cooking. The consumption of the devitaminised grain causes *beri-beri*, a disease common among the rice eating people, particularly of the low income groups, who cannot supplement the rice diet with protective foods. Vitamin B_1 is lost by the removal of the bran layer to a greater extent during milling than during hand pounding. Bran and vitamin B_1 are kept intact in the grain, when paddy is shelled in wooden grinders. Vitamin B_1 diffuses into the grain during par-boiling and par-boiled milled rice is not hence low in vitamin B_1 content like milled raw rice. Hand pounding has, therefore, to be preferred to milling and par-boiled rice to raw rice, for consumption.

Washing rice in several changes of water leads to a great loss of minerals and vitamin B_1 in the wash water, and it has to be avoided or at least reduced to the minimum. Poor quality rice requires more washing and loses these valuable ingredients to a larger extent than good quality rice.

SPECIAL TYPES OF CULTIVATION

1. Udu cultivation. In the low lying areas of the Tanjore delta subject to stagnation of water during the

N. E. monsoon period, two varieties of rice are grown together. The seeds of 'Kuruvai' and 'Ottadan' varieties are mixed together in the ratio of 4 : 1 and sown in nurseries in June. The seedlings are pulled out when they are about 21 days old and planted very closely, with 3 to 5 seedlings in each hole. 'Kuruvai' comes to harvest in September and 'Ottadan' plants are also cut along with the mature 'Kuruvai'. Small wooden ploughs are sometimes worked in the field, to rake the soil, but this is not general. The 'Ottadan' plants put out new growth and get ready for harvest by January. The 'Kuruvai' yields about 2,500 lb. of grain per acre and the 'Ottadan' 1,000 lb.

Such cultivation, called '*Udu*' cultivation is done in low lying areas, which cannot be ploughed and prepared in the usual way for a second crop, as they are subject to stagnation of water. By adopting this system, preparation of the land for the second crop season is avoided. Farmers take 2 crops of rice, where only one crop can be raised otherwise. Further, the robust 'Ottadan' plants support the 'Kuruvai' plants and prevent them from lodging. A similar system of cultivation prevails in parts of Tenali in the Guntur district.

2. *Double transplantation.* In parts of Nellore, Godavari and Tirunelveli districts, a system of double transplantation of long duration varieties of rice is in vogue. The seedlings are pulled out from the nursery when they are six weeks old and transplanted in a second nursery, 3 inches apart, at 7 to 9 seedlings per hole. The seedlings are pulled out from the second nursery after a month and transplanted in the main fields. The tillers

produced in the second nursery are separated and used for planting.

The double transplantation is a laborious and costly system, but is nevertheless suitable under certain special conditions. When season-bound long duration varieties have to be planted at the proper season, in places where water is received in small quantities alone, early in the season and is not sufficient for puddling the main fields in time, small areas are puddled and planted closely at the proper season. After the full supply of water is received, the main fields are prepared and planted with seedlings from the second nursery.

3. *Ratooning rice.* Low lying areas remain wet and slushy after the harvest of the rice crop in some of the tank fed areas of the Chingleput district and the low water supply position does not warrant a second crop of rice being produced. A variety of rice, called 'Uthirikar' is planted in such lands. After its harvest, the stubbles send up fresh shoots and give a second crop, called the 'ratoon' crop. The fields are weeded once, when the shoots are well above the ground. It gives an acre yield of 1,000 lb. of grain and a little more in favourable years.

4. *Deep-water rice.* The foreshores of the Collair Lake in Krishna district and of certain tanks in the Southern Tamil Nad are ploughed and sown to special varieties of rice, called 'deep - water rice', like 'Kolai Vazhai', 'Vallarangan', 'Hari Sankar', 'Pavindala' etc., with the pre-monsoon showers. The crops establish and start growing by the time water is received in the tanks. They grow rapidly and keep pace with the rising water in the tanks, by elongating the stem. When the rice matures, fishermen go on boats over the Collair Lake and harvest

the ears alone. At the time of maturity of the rice, the crop is damaged by birds, considerably sometimes and the crop is always uncertain. Water recedes at harvest time in the smaller tanks in the southern districts and the crops are harvested in the usual manner. The cultivation of deep-water rice is a common feature in Bengal, Assam and Orissa.

5. *Kole cultivation.* Rice is grown in a peculiar way in the low - lying areas near the sea along the West Coast, called 'Kole' areas in Tiruchur and Ponnani areas of Malabar. Masonry embankments are put up to prevent sea water flowing into the fields. These areas get flooded during the south-west monsoon season. After the rains cease in November, water is baled out from the fields with pump sets and water wheels, called 'chakrams'. The soil is in a loose condition and it is levelled without any ploughing and sprouted seeds of 'Cheera', a 3½ months variety is either sown or transplanted. The crop is irrigated by pumping in water from the adjacent channels. An yield of 1,000 to 2,000 lb. of grain per acre is obtained. The cost of cultivation is rather high and 'Kole' cultivation is not always paying.

6. *Kaipad cultivation.* The lands near the sea in the West Coast region are subject to tidal waves and inundation by sea water. Strong bunds are put up with earth brought from outside, as a protection against the inflow of sea water. The lands are drained thoroughly after the monsoon season and mounds, 2 to 3 feet high and 3 to 4 feet across at the base, are formed in regular rows. The tops of the mounds are worked well with spades and germinated seeds of suitable varieties of rice are sown at 40 lb. to the acre. Seedlings are also planted close to one

another over the mounds sometimes. Water is let in at the top of the mound in the case of sowings and maintained at a depth of 2 to 3 inches for the first 3 days, with suitable bunds all round. Later, water is let in and drained in the night. Frequent watering and draining help to wash the salts from the top soil. When the seedlings are 30 to 40 days old, a weeding is given and the mounds are cut into small bits or pieces, with a few seedlings on each piece and they are distributed evenly over the field. The field is brought to the original level during this operation. The crop flowers in September and the ears alone are gathered in the month of October. Water is kept in the field till January and the cycle of operations is repeated again.

The salt in the top soil is washed down by rains and the water let in, and enables the seedlings to get established in the beginning. As they make growth, they get acclimatised to the higher concentration of salts in the soil gradually. Yields up to 2,000 lb. of grain per acre are obtained. Fish and prawn breeding in the field provide some additional income.

7. *Garden land rice.* Rice is cultivated in garden lands in parts of Chingleput, Salem, South Arcot and Coimbatore districts. Water is kept standing in the field from the time of preparation of the field to the harvest of the crop, as in wet lands. Lifting water with *mhotes* for irrigation of rice involves considerable expenditure of human and cattle labour. It is not economic, but the cultivation is done with surplus family labour in the peasant's household, which cannot be employed otherwise. The rice produced in garden lands is preferred by

consumers, as being more tasty and palatable. It sells at a higher price than wet land rice, by about Rs. 2/- a bag.

8. *Mechanised rice cultivation.* Rice is being cultivated in America and Australia in fair areas now, with the use of mechanical equipment. The lands are dry-ploughed, harrowed and sown with drills, operated with tractors. Seeding is done at 100 to 130 lb. of rice per acre. Individual fields are 4 to 6 acres each and bunds 18 to 24 inches high are put up all round with implements, called 'delvers'. The lands are irrigated and kept moist till the plants are about 6 inches in height. Later, water is kept standing in the fields and the depth of water is increased as the crops make growth. When the fields are weedy, the crops are submerged in water held in the field to a depth of about 15 inches for about a week. The weeds turn yellow during the period and die out. The rice plants turn pale and unhealthy, but recover later, after the level of water is reduced. Water is stagnated in the fields, till the grains reach the milk stage.

Sowing is done by the end of October in Australia and harvesting is done from April to June, and the crop is in the field for 6 to 8 months. An average yield of 92 bushels (=4,600 lb.) per acre is obtained, with the maximum yield going up to 189 bushels. Harvesting is done with machinery. The ear heads are cut, threshed, and winnowed and the cleaned grains are delivered in one operation. The wheels of the heading machine are enclosed and fitted with pneumatic tyres, to prevent the tractor from getting bogged in the mire and the mud from getting in between the spokes. Tractors capable of negotiating the mire, and machinery suitable for puddling rice fields have also been evolved and are in use.

9. *Rice cultivation in Japan.* Japan produces over 3,000 lb. of paddy per acre on the average, while India produces a little over 1,000 lb. only. The conditions prevailing in Japan are similar to those in India, with regard to the smallness in the size of the holdings and their scattered nature. The Government of India are introducing the method of cultivation of rice prevalent in Japan into India and popularising it, with the object of stepping up the yield here.

Japan is in the warm temperate zone between 30° and 45° N. Latitude and has an abundant rainfall, which is also well distributed. The climate is mild, with the average temperature around 80° F. in August, the hottest month of the year and about 35° F. in January, the coldest month of the year. The soils are of a light type resembling alluvia, deficient in phosphoric acid and potash, and not of the fertile class, in general. Yet, high yields of rice are obtained by (1) intensive culture, (2) the extensive use of artificial fertilizers, (3) the use of improved seeds and (4) the widespread and timely control of pests and diseases. The land is dry-ploughed thoroughly or dug with spades, immediately after the harvest of the previous wheat or barley crop. Water is let in later and the fields are puddled with hand harrows, bullock cultivators, or sometimes with light tractors. The fields are levelled with hand levelling boards finally. Green manuring is not common, but artificial fertilizers supplying up to 80 to 100 lb. of nitrogen, 35 lb. of phosphoric acid and 40 lb. of potash are applied to an acre. Half the nitrogen and the entire quantity of the other fertilizing ingredients are applied at the time of puddling. A quarter of the total nitrogen is applied 4 to 5 weeks after

planting and the last quarter 4 weeks before the flowering of the crop.

Seed-beds are brought to very good tilth and long narrow beds, 3 to 4 feet wide, raised 3 inches above ground level are formed, with pathways, one foot wide, in between adjacent beds. They are manured with compost and artificials, supplying 1 lb. nitrogen, ½ lb. phosphoric acid and ½ lb. potash per cent of nursery. Seeds are sown at 3 to 4 lb. per cent in lines 2 to 3 inches apart, running across the width of the beds, to facilitate weeding. Heavy seeds, which sink on immersion in common salt solution made with one part of salt and 5 parts of water by volume, are used for sowing.

Seedlings, which are 34 to 40 days old, are transplanted in the field with a spacing of 10″ x 6″ ordinarily and with 10″ x 10″ at the extreme end. The crop is hand weeded 15 days after planting and intercultured 3 or 4 times later, with hand rotary weeders, keeping about ½ an inch of water in the field. Water is drained after heading of the crop. The mature crop is harvested, taken home and the grains are separated with threshers worked with feet or with power. The paddy is shelled and stored as brown rice. Pests and diseases are tackled, as they appear with sprayers and necessary chemicals, which are available readily with the village co-operatives.

10. *The modified Japanese method.* In what is called the 'modified Japanese method of cultivation of rice' in South India, the following are the essential features.

The seed beds are prepared thoroughly and sown with 3 lb. of seed per cent of nursery, a little more for coarse varieties and a little less for fine varieties. They are

weeded and irrigated, when necessary. Seedlings are pulled out from the nursery 25 to 35 days after sowing, allowing one week of nursery period for every month of duration of the variety concerned. The field is manured with 4 to 6 cart-loads of green leaves or 10 to 15 cart-loads of cattle manure. Superphosphate is applied in the furrows at the time of the last ploughing, before levelling, at 150 lb. per acre. Seedlings are transplanted in the field at 3 to 5 seedlings per hole, 4 to 9 inches apart, closely for short duration varieties and widely for long duration varieties. Ammonium sulphate is applied at 150 lb. per acre, at the time of the first weeding. In areas subject to the incidence of the 'Blast' disease, the application of ammonium sulphate is, however, limited to 100 lb. per acre. The soil around the plants is loosened with the foot at the time of weeding.

This method is what the Madras Agricultural Department has been advocating for a long time now, based on the results of experiments conducted in the composite Madras State for over 40 years and not based on what has been or is being done in Japan to push up the yield of rice. To call it the 'Modified Japanese method of cultivation of rice' is curious and anamolous, as it is truly the 'Madras method of cultivation of rice' alone. It is not an adaptation of the Japanese method, though both have many points of similarity and lay equal stress on certain definite fundamental principles. The essence of the Japanese method is intensive fertilization with 80 to 100 lb. of nitrogen to the acre and this dose is too high for South Indian soils, where the crop lodges badly when fertilized with anything over 30 lb. of nitrogen per acre. The thin nursery and economic planting are basic features of rice cultivation, both in South India and

Japan. The selection of heavy seeds for sowing and intensive manuring of nurseries are not specially necessary or advantageous under the conditions prevailing in South India. Experiments conducted previously in Madras have shown clearly that these two practices are without any appreciable effect on the yield of rice here.

VI. 2. - Sorghum (*Sorghum vulgare* Pers.)

Vernacular names: Tamil and Malayalam - cholam; Telugu - jonna; Kannada - jolla; Hindi - jowar.

Origin. The word 'sorghum' is derived from the Italian word 'sorgo', which means 'rising above', that is, above other crops in the field. It is a tall crop, which grows to a height of 4 to 12 feet. It is also known as the 'great millet', as it is the largest of the common small food grains, called 'millets', with regard to both the size of the crop and the grain. Many wild forms of sorghum allied to the cultivated forms are found in India and Africa and it is probable that India along with Africa may have been the original home of the sorghums.

Importance. Sorghum is the staple food of the poor people in all regions, where it is grown as a major crop. It is superior to rice and richer in protein, though not so tasty; the ratio of straw to grain is also greater. The straw is fairly good and nutritious, and superior to rice straw, the major staple fodder in South India. It is an important grain and fodder crop in low rainfall and scarcity areas all over the world.

Adaptation. Sorghum is essentially a tropical crop, which thrives in regions having a mean temperature of over 80° F. It is not capable of adapting itself to altitudes

above 4,500 feet above sea level or to a minimum temperature below 60° F.

It is an extremely drought resistant crop, which comes up fairly well in regions of low and uncertain rainfall. It regulates transpiration and remains dormant during periods of drought and starts active growth, when the moisture status of the soil becomes satisfactory again. It is very hardy and adaptable to conditions of extreme aridity and high atmospheric temperature not possessed by any other crop plant. Consequently, considerable research has been directed to the evolution of dwarf types in America, called 'milos' and 'dwarf milos', which are cultivated extensively in low rainfall regions in America and Australia, for the production of grain for feeding stock and the straw is not much valued in these countries. The large sorghum areas of the world are in low rainfall regions of 20 to 30 inches. It is a major crop in the Ceded districts region, and Coimbatore and Salem districts, where the rainfall is low. It comes up very well under conditions of medium rainfall as along the Circars coast, which has an annual rainfall of 30 to 40 inches. It does not tolerate heavy rains, as are prevalent in West Coast.

Sorghums, along with other millets, are short day plants, stimulated to flowering by short day periods. Those cultivated during short day periods have a long duration and a large leaf surface. Those grown in long day periods, as in summer, have a shorter duration, shorter stems and smaller leaf surfaces. They are also sensitive to nitrogen and are stimulated to early flowering by ample available nitrogen in the soil.

Distribution. The total area under sorghum is about 80 million acres in the world. Sorghum ranks third in extent among the grain crops, coming after wheat and rice. It is grown extensively in India, Manchuria, China, and Africa and in limited areas in South European countries, America and Australia.

Sorghum occupied an estimated area of 42·99 million acres in India during 1953—'54. It is next in importance to rice as a grain crop. It is concentrated in Central and Peninsular India, with Madhya Pradesh having 15·01 million acres, Bombay 11·27 millions, Hyderabad 9·19 millions, Andhra 2·82 millions, Uttar Pradesh 2·28 millions, Madras 1·72 millions and Mysore 1·04 millions, while the other States have small areas only.

The normal extent of sorghum cultivation in Madras and Andhra States is given below, district-wise:

MADRAS		ANDHRA	
District	Extent in acres	District	Extent in acres
Chingleput	6,530	Srikakulam Visakhapatnam	55,570
South Arcot	111,440		
North Arcot	86,050	East Godavari	73,730
Salem	241,930	West Godavari	49,800
Coimbatore	461,060	Krishna	201,040
Tiruchirapalli	274,410	Guntur	451,990
Tanjore	440	Kurnool	553,560
Madurai	299,160	Anantapur	306,470
Ramanathapuram	44,340	Cuddapah	277,540
Tirunelveli	78,040	Nellore	370,470
Malabar	600	Chittoor	34,750
Nilgiris	50		
Total (Madras)	1,604,050	Total (Andhra)	3,052,310

Irrigated sorghum occupies 40 to 100 thousand acres in each of the districts, Madurai, Coimbatore, Salem, Tirunelveli and Tiruchirapalli and fair areas in the other districts of the Madras State. It occupies small areas only in Andhra Desa. Irrigated areas are 397,000 acres in Madras and 86,000 acres in Andhra, representing about a fourth of the total sorghum area in Madras and less than 3 per cent in Andhra.

Soils. Sorghum is essentially a crop of the heavy soil, and is the most prominent cereal in the tropics. It is also grown in light red soils and makes good growth, under favourable conditions of rainfall. Excellent sorghum crops can be seen growing in red soils at the foot of the Marudamalai and Velliangiri Hills in the Coimbatore district. It attains gigantic proportions in the deep alluvia of the Godavari *lankas*, or the small islands formed on the Godavari River bed. It tolerates alkalies and salts in the soil to some extent.

Season. Sorghum is cultivated as a rain-fed crop, mainly in two seasons in South India, during the south-west and the north-east monsoon periods respectively. The sowings are done at different times in the various regions depending upon the intensity and distribution of the rainfall. The seasons have various local names, which are confusing to those not conversant with the dialect. They may, therefore, be called 'early' and 'late' seasons in a general way.

Sorghum can be grown right through the year under irrigation, though in practice, the sowings are confined to December-January and March-April.

The early season sowings in dry lands are done with the commencement of the south-west monsoon rains in

the light red soils and late sowings with the north-east monsoon rains in the heavy black soil areas. The early sowings commence even with pre-monsoon showers in favourable localities, as at Pollachi in the Coimbatore district and the late sowings with the break-off of the north-east monsoon, as at Bellary. The time of sowing is influenced by the distribution of the rains, the nature of the soil and the duration of the crop. The objective is to have the flowering of the crop during non-rainy periods and the harvest during a period of clear weather. Rainy weather during flowering affects pollination and seed setting. Humid weather during the period of the development of the seed predisposes the crop to damage by the sugary disease of the ear heads.

Seasonal periodic winds are known to be beneficial to sorghum crops. The north-east wind, called 'bhodanam', 'vayuvu mula galli', or 'parvatha galli' in Guntur and the Ceded districts during the milk stage of the grains assures freedom from pests and diseases and promotes the healthy development of the grains and is thus beneficial. Similarly, the 'pyru galli' or the south-east wind blowing from December to February is considered beneficial. The 'uppam kathu' blowing from the sea in January and February promotes the growth of fodder sorghum grown in the black soils of Tirunelveli.

Varieties. The varieties of sorghum cultivated in South India can be classified as follows :

1. *Sorghum durra* Stapf. var. *Coimbatoricum.* Snow.—'Peria manjal cholam' of Coimbatore and other medium compact headed varieties,
2. *S. cernum* Host. var. *globosum*—'Thella jonna' of Bellary,

Fig. 17. Winnowing grain with hand-winnows.

—*Courtesy: Director of Agriculture, Madras.*

FIG. 18. A good sorghum crop.

—*Courtesy: Director of Agriculture, Madras.*

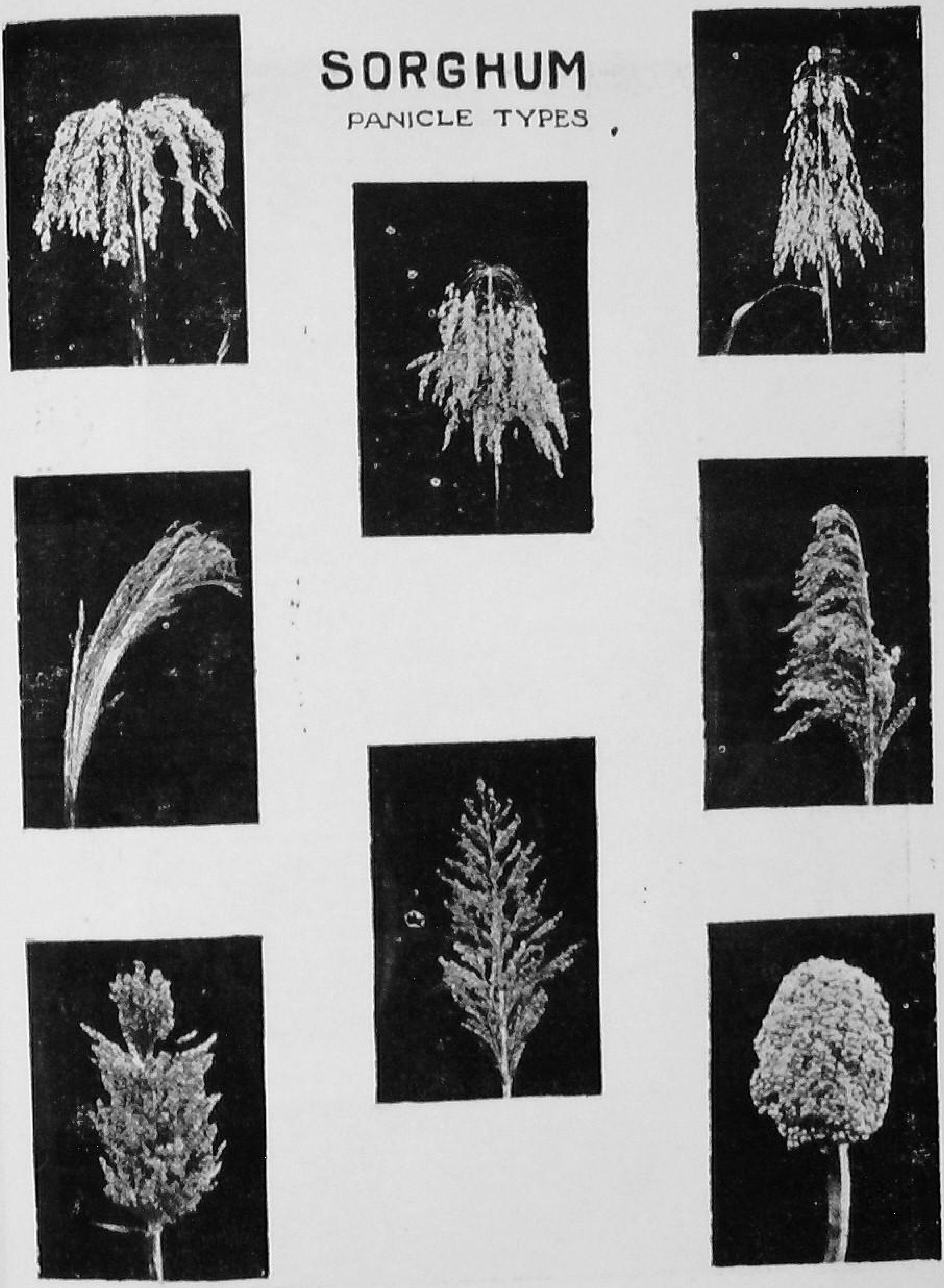

Fig. 19. Pancile types in sorghum.
—*Courtesy*: *Director of Agriculture, Madras.*

FIG. 20. Threshing sorghum under the feet of cattle.

—*Courtesy: Director of Agriculture, Madras.*

3. *S. subglabrescens* var. *irugiforme*—'Peria vellai' and 'Chitrai vellai' *cholams* of Coimbatore,

4. *S. subglabrescens* var. *compactum*—'Chinna manjal' *cholam* of Coimbatore,

5. *S. durra* var. *mediocre*—'Pacha jonna' of Nandyal,

6. *S. roxburghii* var. *hians*—'Thalai virichan' *cholam* of Coimbatore,

7. *S. dochna* var. *irungu* and *melliferrum*—'Irungu' *cholam* of the southern districts in Tamil Nad, and

8. *S. dochna* var. *obvatum*—'Chen cholam'.

Sorghums are classified in U. S. A. as follows:

I. Annuals –1. sweet sorghums or 'Sorgos' for fodder, syrup-making and chewing,

2. grain sorghums— 'Kafir' and 'Milo' for grain,

3. grass sorghums (Sudan grass and Tunis grass) for pasture and forage, and

4. broom corn, for making brushes out of the empty ear heads.

II. Perennials. *S. halapanse* (Johnson's grass) for forage.

Sorghums are classified locally with some prominent morphological character as the basis, as follows:

1. *Colour of grain or glume*—'Thella' (white), 'Pacha' (yellow), 'Yerra' (red), 'Kaki' (black) *jonnas;* 'Yennai vellai' (oily white), 'Mathappu'

(bright like fire works) and 'Mapillai' (showy like bridegrooms) *cholams,*

2. *Panicle shape—*

   (*a*) *compact ears*—'Gundu pacha jonna' (compact yellow sorghum) of Nandyal and 'Uppu katti cholam' (sorghum with ears firm like salt bag) of Tirunelveli,

   (*b*) *loose heads*—' Kudirai val irungu cholam' (loose and hanging ears like the tail of horses) of Tiruchirapalli, 'Thalai Virichan cholam' (ears spread out like dishevelled hair) and 'Sadai cholam' (ears with pleated appearance),

   (*c*) *Cylindrical heads*—'Devarra Jonna' (shaped like *Siva lingam,* that is, cylindrical),

3. *Duration*—'Peria manjal cholam' (long duration) of Coimbatore and 'Pedha Jonna' (long duration of Krishna),

4. *Number of leaves or nodes*—'Yedakku Jonna' (seven-leaved) of Kurnool, 'Moonu kannu cholam' (three-noded sorghum) and ' Moonu gannika Jonna' (three noded sorghum),

5. *Season of growth*—'Mungari' and 'Punasa' (early), 'Hingari' and 'Pairu' (late), 'Chitta Jonna' (sown in *Chitta Karthi*); 'Thai cholam' (sown in January—February), 'Agni kodai cholam' (grown in summer with the sun blazing like fire),

6. *Locality*—'Konda Jonna' (sorghum grown in hills) and 'Thota pacha jonna' (garden land yellow variety), and

7. *Flavour and taste of grain*—'Chakkarai gulikai jonna' (sweet like sugar pills) of Hospet, 'Thuvar cholam' (astringent), 'Cheruku jonna' and 'Kabbu jola' (sweet stalked like sugarcane).

Cherukku jonnas or sweet sorghums have juicy stalks and the mid-ribs of the leaves are dull white and pearly in appearance and both the grain and straw are of high quality. *Bendu jonnas* or pithy-stalked varieties have hollow, pithy and insipid stems and the mid-ribs of the leaves are white and chalky in appearance. They are mostly grain varieties and the straw produced is of poor quality. Sweetness, or insipidity of the stem can be combined with either juiciness or pithiness. Sweetness and pithiness have gone together in most varieties, while sweetness and juiciness are combined in a few varieties alone, as in the 'Thella jonna' of Bellary. Similarly, insipidity and pithiness are combined in a few varieties alone, as the 'Thalai virichan cholam' of the Central districts. The straw of this variety has a very low feeding value and it is not palatable to stock and is consequently rejected by them.

A number of varieties of sorghum are grown in South India and the following are some of the more notable ones:

1. *'Thella jonna'*. This is the prominent variety grown largely in Bellary, Anantapur and the western parts of Kurnool. It does not set seed in other regions. The ear heads are compact, rounded and hard to the feel, and the grains are pearly white. The plants are of medium height, the stem is juicy and sweet, and the straw is leafy. They do not flower in unfavourable seasons. They are sown in September—October, practically after the close

of the monsoon rains and are harvested in January—February. Both the grain and straw are valued for their palatability and taste. The grain lends itself for being made into *chappathis* (thin unleavened bread) of good quality.

2. *'Pacha jonna'*. This is grown in Nandyal valley, between the Yerramalai and the Nallamalai hill ranges. It is sown in August—September in the black soils and has a duration of 4 months. It grows vigorously to a height of 7 feet and gives a heavy yield. The straw is of good quality and is leafy. The ear heads are moderately long, bright yellow, plump and heavy. They are compact in general, though they tend to be of an open type in the southern region, where the rainfall is higher. The grain is tasty and particularly suitable for making *jonna rotties* (pan cakes) of a thick type. 'Cherukku pacha jonna' is a sub-variety, whose stalks are sweet.

3. *'Pedha jonna'*. This is a tall variety, which is sown in the red soils of Bellary, parts of Kurnool, Krishna and Godavari districts in September and harvested in February, after a period of 5 months. It has a slow growth habit, but grows to a height of about 8 feet. The ear heads are rounded and hard to the feel, with the grains set closely. Both the grain and straw yields are high.

4. *'Peria manjal cholam'*. This is the principal variety of yellow cholam grown in Palladum and Coimbatore taluks in both red and black soil areas. It is sown from July to September, early in the red soils and late in the black soils. It grows to a height of 10 to 12 feet and the straw yield is rather high. Leaves are large in size and persistent, and the straw is consquently of good feeding

quality. The ear heads are of a semi-open type, about 5 inches long and the glumes are red, black or brown, and do not get separated from the grain easily. The grains are bright yellow in colour and tasty.

5. *'Irungu cholam'*. This is a fodder variety grown mainly in the region south of Tiruchirapalli. The glumes are black, brown or red in colour, persistent and enclose the grain completely. It is therefore called 'Kan-moodi cholam', that is, the cholam which has the appearance of closed eyes. The grain is of poor quality and slightly acrid to the taste, but the crop is grown only for its fodder. It is sown rather thick and the plants are close to one another. Consequently, the stalks are thin, one-fourth to an eighth of an inch in diameter and is consumed by cattle with relish and without wastage.

Rotations. Different crops are grown on the land, one after another, but not in any sequence or order and regular rotations may be said to be non-existent, in general. Many types of cropping can be seen. Sorghum is grown once in 3 or 4 years in dry lands, followed by other crops. In the Godavari and Krishna *lankas*, tobacco and chilli are grown in rotation with sorghum, while in the black soils nearby, cotton and *ragi* (*Eleusine coracana*) are the crops in the rotation. In the Ceded districts, cotton and groundnut are rotated with sorghum in a 3-year rotation and cotton, groundnut or horsegram is alternated with sorghum in a 2-year rotation. In Salem, groundnut, cotton, *ragi* and *cumbu* (*Pennisetum typhoides*) are the other crops in the rotation. Sorghum is alternated with cotton in the dry areas of Coimbatore and occasionally Bengalgram is interposed between cotton and sorghum. In Pollachi of the same district, groundnut is

sown in April-May and followed by a crop of fodder sorghum in the north-east monsoon season. In the southern districts of Madurai, Ramanathapuram and Tirunelveli, fodder sorghum is grown year after year in the poor grades of black soils. A 4-course rotation, cotton-*cumbu*-cotton-fodder sorghum, is also adopted here and there rarely.

In the garden lands of Coimbatore, sorghum is followed by Cambodia cotton and later by *ragi* in a 2-year—3-course rotation. *Panivaragu* (*Panicum mileaceum*), wheat or tobacco is included once in a way, as the fourth crop in the rotation.

Mixtures. In the hilly areas of Visakhapatnam and Godavari, shifting cultivation is in vogue and sorghum is grown as a mixed crop in association with various pulses, oil seeds and even dry rice. Sometimes, cereals like *tenai* (*Setaria italica*). *samai* (*Panicum miliare*), *varagu* (*Paspalum scrobiculatum*), 'Budama' rice etc., replace the pulses and oil seeds in the mixture. In the Godavari and Krishna *lankas*, lablab, blackgram, greengram, horsegram, gingelly and *gogu* (*Hibiscus cannabinus*) are mixed with sorghum. A variety of cucumber, called 'Nakka dosa kaya' (*Cucumis melo* Lin. var. *utilissima*) is mixed with sorghum in Andhra Desa. *Pillipesara* and dewgram (*Phaseolus aconitifolius*) are mixed with sorghum grown for fodder. In the central districts of Chittoor, North Arcot and South Arcot, sorghum is a minor crop and it is mixed with groundnut, redgram and *ragi*.

Preparatory cultivation. Dry lands are ploughed in March-April in Tamil Nad, on receipt of summer rains and later at suitable intervals, usually 2 to 4 times, depending upon the farmer's convenience and the time available.

If summer rains withhold, the land is ploughed after the receipt of the seasonal monsoon rains, and the seeds are broadcasted and covered by ploughing and levelling.

Garden lands are ploughed immediately after the harvest of crops, when there is some moisture in the soil. If the moisture is not sufficient and if the land has to be prepared immediately for the next crop, it is moistened with a light irrigation and taken up for ploughing, when in condition. The land is ploughed 2 to 4 times, ordinarily.

In the Guntur area, seed drills without sowing attachment, and blade harrows are worked alternately for preparing the field for early season crops. The lands are ploughed twice or thrice for late season crops and finally worked with blade harrows, with the blade slightly turned upward, for compacting the soil. Ploughing the field diagonally is a practice peculiar to the district and the farmers claim that it helps to uproot the stubbles of the previous cotton crop. It appears to be a traditional practice, without any solid basis.

In the Ceded districts, red soils are ploughed once or twice and later worked with blade harrows. In black soils, the previous cotton crop is uprooted by working blade harrows once or twice. This is the only preparation the land receives. Recent experiments indicate that ploughing the soils in this region is not of any special advantage. Formerly, lands foul with *hariali* grass (*Cynodon dactylon*) were being ploughed with big wooden ploughs drawn by 5 or 6 pairs of bullocks, once in 5 or 6 years, immediately after the harvest of the previous crop, before moisture in the soil was lost by evaporation. The wooden ploughs have now been superseded by iron

mouldboard ploughs drawn by 4 pairs of animals. When land is left in clods by deep ploughing, the *hariali* grass with its stoloniferous roots are dessicated by the extreme heat prevailing in summer, along with the clods. The lands are worked with blade harrows after the receipt of rains and the clods are broken. Later, seed drills are worked 3 or 4 times and the lands are brought to condition for sowing the next crop. The sorghum crop requires a firm seed-bed and a fine tilth is not so necessary as for other crops and ploughing the lands repeately is not economic. It is also not possible to plough the lands every year, as the number of plough bullocks available in the region is limited and 30 to 40 acres have to be managed with one pair of animals.

Manuring. Dry lands are not usually manured in low rainfall regions. In parts of Kurnool and Guntur which have a medium rainfall of 30 to 35 inches annually, 3 to 5 cartloads of cattle manure are applied to an acre and covered by working blade harrows. Extensive holdings are manured in rotation, a few acres each year, with the manure available. Penning sheep and applying tank silt are common practices in Tamil Nad. Organic manures, like cattle manure and compost, are the safest manures for dry lands in low rainfall regions. Artificial fertilizers are of great assistance in pushing up the yields in regions of adequate rainfall and their use in low rainfall areas is likely to be uneconomic; it may even depress the yield and be harmful.

Cattle manure, municipal rubbish, or compost at 10 to 15 cart-loads per acre and tank silt are applied regularly to irrigated sorghum crops. Sheep penning is also done. They assist in maintaining the fertility of garden

lands at a high level and can be supplemented advantageously with 3 cwts. of ammonium sulphate and 1·5 cwts. of superphosphate per acre.

Sowing. Sorghum is raised by (1) broadcasting, (2) drilling, (3) sowing in plough furrows and (4) transplanting.

1. Broadcasting. This is the most common method of sowing sorghum in Tamil Nad and the seeds are covered by working wooden ploughs. One man can broadcast 8 to 10 acres in a day. Seed rates of 10 to 15 lb. to an acre are in vogue for grain crops; the lower rates for dry crops and the higher ones for irrigated crops. Broadcasting requires more seed than drilling, for obtaining the same stand of crops. The broadcasted seeds are laid at different depths, when they are covered by ploughing and all of them do not have the same chance for germinating, which explains why a large seed rate has to be adopted.

In garden lands, beds are formed after covering the seeds, with a channel between every two rows of beds. Water is diverted for irrigation from the channels to the beds on both the sides.

2. Drilling. This method prevails in the Ceded districts and the Circars region. Red soils are drilled earlier in the season with the commencement of the south-west monsoon and the black soils later, with the north-east monsoon. When the moisture in the soil is at a satisfactory level, 6 tined drills are used and the seeds are laid near the surface. When it is low, 3 tined drills are used. In mixed cropping, the main crops are sown with the drill, but the hole in the seed hopper intended for the subsidiary crop is blocked. Subsidiary crops are

sown through special seed tubes, called '*akkadies*', in the appropriate furrows opened already by the drill tines. The Method of attaching them to gorrus is shown in Fig. No. 6, page 47. The seeds are covered by working blade harrows, with the blades skimming over the surface, so as not to disturb the seeds deposited by the drills. When the moisture in the soil is at the marginal level, the blade harrow is worked repeatedly, with the blade turned upward for compacting the soil and promoting germination. When the soil is over moist, a brush harrow is dragged over the field, across the furrows made by the drill, for covering the seed.

The seed rate adopted for drilling sorghum ranges from 6 to 10 lb. to an acre. Higher seed rates are used for light soils and regions of low rainfall, where the crops do not make vigorous growth and cover the ground readily. The lower seed rate is used in heavy black soils, which are fertile and retentive of moisture, and which promote good growth of crops. Experiments, done at the agricultural research station at Hagari, indicate that the best yields can be had with a spacing of 2 feet between sorghum rows. The spacing adopted in parts of Kurnool is 2½ feet between rows and this is an extremely wide spacing. The normal spacing ranges from 13 to 18 inches between lines. The spacing given depends upon the soil, the capacity of the soil to retain moisture, the rainfall that is received during the growing period and the inherent fertility of the soil.

3. *Sowing in furrows.* Sorghum is sown in plough furrows rarely, when the lower layers of soil are sufficiently moist and the surface layer is dry, with the object of providing conditions favourable for germination.

4. Transplantation. Sorghum is transplanted in the Circars region, Nellore, Cuddapah, North Arcot, Tiruchirapalli and Ramanathapuram districts. The method adopted in dry lands consists of ploughing the field and dropping seedlings raised in nurseries in an inclined position, with regulated spacing between them along the furrows and resting on the sides of alternate furrows. The roots of the seedlings are covered by the earth pushed aside when the next furrow is opened. The seedlings establish properly when transplantation is done during rainy weather. The transplanted crops do not grow as much as those raised by direct sowing, but the ear heads produced are plump and there is a slight improvement in grain yield.

In garden lands transplantation is done in a different way. The fields are laid into beds, with irrigation channels in between, for leading water. The beds are flooded one after another, with water lifted from wells and the seedlings are held between the thumb and the fore-finger and pushed into the wet soil, 7 to 9 inches, apart each way, with water standing in the beds. The holes made, while inserting the seedlings, are filled by dragging the wet mud with the other fingers, while withdrawing the fingers from the holes.

After-cultivation. The seeds sown do not germinate evenly over the field, always. Further, the young seedlings are sometimes damaged by beetles and grass hoppers. These bring about gaps in the field which, when considerable, are filled by dibbling seeds or by transplanting seedlings during rainy weather. In garden lands, sorghum plants spring up thick, where the seeds get collected at the time the beds are formed and

levelled. These crops are, therefore, thinned when the plants are about 9 inches in height. The spacing, allowed between adjacent plants at the time of thinning, is 6 to 8 inches. Rain fed crops do not ordinarly require thinning.

Drilled crops are intercultivated with blade harrows of suitable width, in between crop rows, when they are 3 or 4 weeks old and later after another 3 weeks. The crops develop nodes thereafter and further intercultivation is liable to break the stems and be harmful. Broadcasted crops are hand-hoed and weeded once or twice, depending upon the extent of weediness. Irrigated sorghums are hand-hoed after 3 weeks and later hoed with spades, when the plants are 12 inches in height, in regions where heavy winds prevail during the ear head stage. At the same time, the plants are also slightly earthed up on the windward side, to promote the formation of secondary stilt roots for anchoring the plants firmly.

Irrigation. Garden land sorghums are irrigated on the day of sowing. The second irrigation, called the 'sprout irrigation' is given on the third or fourth day, for softening the surface and assisting the emergence of the sprouts through the soil without difficulty. This is specially important, where the soil cakes up on drying and forms a hard crust on the surface, as in alkaline and clayey soils. Transplantation of seedlings is done after an irrigation. The second irrigation given in this case is after 3 to 5 days, depending upon the weather conditions, except when there is rain. If it is delayed and the moisture content of the soil falls down, the seedlings do not get sufficient moisture for their sustenance, many of

them die and a poor stand results. In view of its role in sustaining the life of the seedlings, it is called 'life irrigation'. The next irrigation is given after another 3 weeks, allowing the weeds left uprooted by the first hoeing to dry up. Subsequent irrigations are given at intervals of 10 to 15 days, depending upon the moisture held by the soil and the condition of the crop. Frequent heavy irrigations induce the growth of straw at the expense of the grain. Irrigation is particularly necessary at the time of formation and development of the grain and it determines the size of the grain and the final yield to a large extent. Irrigation is not necessary, when the grain is hardening and drying.

Irrigation experiments conducted at the Central Farm, Coimbatore, indicate that sorghum raised in loamy soils, during summer requires about 22 inches depth of water in all, for giving the maximum yield and that 3 inches depth of irrigation given every fortnight meets its requirements normally. It requires 4 to 6 irrigations, depending upon the prevalence of summer rains. Irrigated crops mature a little earlier than dry crops sown simultaneously. The grain and straw of irrigated crops are inferior to those produced in dry lands, with regard to quality, palatability and nutritive value.

Scaring birds. Birds peck the grains in the early stages of development and do considerable damage sometimes. Elevated platforms are erected in fields, for boys to stand and scare birds by shouting, pelting stones with slings and catapults, and by hitting empty tin containers and making noise. Shining metal foil pieces, loosely hung from high poles planted in different parts of the field, dangle about with the wind and reflect light, which scare the birds.

Harvesting. Sorghum crops are harvested when the grains mature and get hard. The ear heads are separated in one lot from the standing crop, when it is less than 6 feet in height and the stalks are cut later, leaving 6 to 9 inches of stubbles on the ground. If the stubbles are shorter, the sharp ends of the hard stalks injure the feet of men and cattle working in the field. The plants are pulled out with the roots in some places, to enable ploughing being done later, without inconvenience from the standing stubbles. The stalks have to be cut, soon after the removal of the ears, as otherwise they get more fibrous and less digestible day after day. There is also a flow-back of nutrients from the mature plants into the soil and the feeding value of the stalks is lowered.

When the crop is more then 6 feet in height, it is cut and laid in sheaves regularly over the field, for drying. The ears are separated from the stalks after 3 or 4 days and threshed. The straw is tied into small bundles and stooked in the field in regular rows, so that the inter-row spaces can be ploughed up, with the moisture present in the soil. Stooking consists of keeping a few straw bundles together, resting over one another and standing vertically with the butt ends on the ground. The straw is stacked after it gets dry. The stacks are built on elevated ground which is not subject to stagnation of water during rains, over wooden scantlings supported on stones, to avoid damage by white ants.

When sorghum is grown mixed with pulses, the ear heads are gathered and the stalks are cut later, after the pods are picked from the pulse crops.

Threshing. Sorghum ear heads are spread out on the threshing floor for drying and threshed later. The heads

are struck with sticks, bent near the end like hockey sticks, for separating the grains. These are collected and cleaned by winnowing. One man can thresh 500 to 600 lb. of grain in a day. Hand-threshing is suitable, only when small lots are handled.

Cattle-threshing is the more common method of separating the grains from the ears. The heads are spread out in a circle, 10 to 20 feet in diameter, on the threshing floor to a thickness of 9 to 12 inches and trodden by cattle. The animals are muzzled to prevent them from picking up the ears, while treading. If the layer of ear heads is laid thicker, cattle find it difficult to walk and if it is thinner, the separated grains tend to get broken. When the animals tread the ears, the grains get separated. The empty ear heads are collected and stored for use as cattle feed. The grains are gathered and cleaned by winnowing. A team of 4 animals can separate about 2,000 lb. of grain in a day.

In the Ceded districts, the ear heads are spread out in a circle about 18 feet in diameter and stone rollers are taken round and round over the layer of ear heads with a pair of bullocks for separating the grains. The rollers are roughly cylindrical, 3 feet long and about 18 inches in diameter, tapering towards the two ends with a slight bulge in the centre. Their weight is about 1,000 lb. each. The ears are kept raked with wooden rakes, called 'kanki danti', during threshing. A pair of bullocks can thresh about 6,000 lb. of grain in a day.

Machines are seldom used for threshing grains in India. Many types of threshing machines are in use in other countries and a few types have been imported into India for trial. The ears are fed to the threshing

machine at one end, threshing, cleaning and winnowing are all done in one operation and the cleaned grains are delivered through a spout, ready for bagging. The power and labour required for operation vary with the type and size of the machine and 8,000 to 16,000 lb. of grain can be separated in a day.

The glumes are firmly adherent to the grains and are persistent in certain varieties. as in 'Irungu cholam'. They do not get separated during threshing. They are adherent to immature grains in other varieties also. They are then separated by pounding the grain in stone mortar with wooden pestles.

Winnowing and cleaning. Glumes and chaff are mixed with the threshed grains and have to be separated by winnowing, as in the case of rice. Small hand operated winnowing machines can also be used for the purpose; a few of them are in use in the Coimbatore district, where garden land cultivation is common and the harvest of the different crops is spread over the year, and the machines are used for winnowing grains in non-windy seasons. The machines have sieves for separating the grain from the chaff and dust. Three women and one man operating a unit can clean 3,000 lb. of sorghum in a day. The quantity of grain cleaned varies with the crop; 1,000 lb. of paddy, 2,250 lb. of *cumbu* or 1,500 lb. of *ragi* can be winnowed and cleaned in a day.

Storage of grain. Small quantities of sorghum grain are stored in gunny bags or in earthen bins. Large quantities were being stored formerly in underground pits, 5 to 10 feet square and 4 to 12 feet deep, lined with dressed stones and covered with a stone slab, provided with a man-hole. The pits were filled with grains, the

man-hole was covered with another slab and finally protected with a layer of earth. The pits were opened when required and aerated for a time, to allow the carbon dioxide accumulated in the pit, to escape, before removing the grains. The grains lose their viability in a short time in underground storage, but remain wholesome and fit for consumption as food for about 3 years, without getting weeviled and mouldy. With the development of marketing, and rail and motor transport, the necessity for storing grains locally in pits for use in times of scarcity, famine and failure of crops has disappeared. The surplus grains are sold within a short time of harvest, after reserving the quantity required for consumption during the year and for seed purposes during the next season.

Sorghum grain is easily damaged by weevils and grain moths during storage and requires periodical drying in the sun. The surface of the gunny bags holding the grain can be dusted over with B. H. C. preparations, for repelling storage pests.

Yield. The yield of sorghum varies widely and the following may be taken to represent the average range, under different conditions in South India:

Locality	Yield in lb. per acre		Remarks
	grain	straw	
Ceded districts	200 - 300	800 - 1,000	Dry crop
Other districts	300 - 500	1,000 - 1,500	Dry crop
Do.	1,500 - 2,500	5,000 - 8,000	Irrigated crop

Fodder sorghum. Sorghum is commonly cultivated as a grain crop and the straw obtained is used as cattle feed.

It is cultivated solely as a fodder crop in isolated regions only, as in Madurai, Ramanathapuram and Tirunelveli districts, where it is grown mixed with dewgram. The dewgram is cut in the green state in stages and used for feeding cattle. The lands are manured by penning sheep at 2,000 sheep per acre and sorghum is sown thick, at 100 to 150 lb. of seed per acre, with the advent of the north-east monsoon. The plants are very close to one another and the stalks produced are very thin. The grain produced is limited to 100 to 150 lb. an acre, a quantity that is just sufficient for sowing about an equal area next year. The fodder produced is of very good quality. It is practically the only fodder produced in the tract. The main cereal crop of the tract is *cumbu* and its straw is coarse, pithy and unsuitable for use as a regular cattle fodder.

Sorghum is raised as a fodder crop under rain-fed conditions in parts of Guntur and Nandyal, during the south-west monsoon season and under irrigation during summer in small areas in the Central districts, for providing some green fodder for cows and *mhote* bullocks. Fodder sorghum can be ratooned, but the young growths are poisonous and can be used, therefore, only after the crop flowers.

Chaffing fodder. Apart from what is actually consumed, a considerable quantity of fodder is pulled down by stock and soiled with dung and urine lying about on the floor of the stall and wasted. Sorghum straw is therfore cut into pieces of about a foot in length at the time of feeding. It was seen from some trials conducted at the Central Farm, Coimbatore, that cattle consumed sorghum straw, cut into small pieces of ½ to 2 inches

with chaff cutter, to the extent of 20 per cent more than long uncut straw. The total straw required, that is, the quantity consumed and wasted by the cattle tegether, was about 16 per cent less with chaffed material than with long straw. It is therefore advantageous to chaff sorghum straw, or cut it into small pieces, before feeding. A medium sized power chaff cutter can chaff 1,000 lb. sorghum straw per hour and a hand cutter 150 lb.

Sorghum for syrup. The sorghum stalks are sweet and contain varying quantities of sugars. Sweet sorghums, called 'sorgos' are very sweet and taste almost like sugarcane. The sorgo juice contains 13 per cent of sucrose and 5 per cent of glucose. It is made into syrup on a small scale in America for use in the kitchen and the confectionery.

Sorghum injury. The growth and yield of crops following sorghum are depressed to a certain extent and this is referred to as 'sorghum injury'. Sorghum is, therefore, said to be hard on the land by practical farmers. Crops following fodder sorghum at Koilpatti gave 15 per cent less yield than those following *cumbu* under similar conditions. The fall in yield can even be higher. Advantage is sometimes taken of this, as when 'Virginia' tobacco is grown after sorghum in the Guntur district, especially in fertile soils. This is of assistance in producing mildness and good colour in the 'Virginia' cigarette leaf.

Various hypotheses are advanced to explain the basic causes responsible for the deleterious after effects of sorghum. It was seen at Koilpatti that when compared to *cumbu,* sorghum left the top soil in a more clayey and alkaline state. The sorghum fields were left in a more

cloddy state after ploughing. They did not crack so freely in summer as the adjoining fields and they were less permeable to rains. The injurious after effects are only of a temporary nature and disappear after a season, whether the land is cropped or left fallow. They are nullified to a large extent when indigo and pulses are grown mixed with sorghum. Indigo is stunted in growth in the beginning, but makes up later after the harvest of sorghum. Grown-up indigo plants are not apparently affected, when they get clipped to some extent at the time of harvesting sorghum. They are ploughed in as green manure later, after the receipt of summer rains.

Sorghum stubbles ploughed into the soil contain a quantity of sugars, which encourage microbial activity. The bacteria in the soil use up all the available nitrogen for their growth and the crops that follow are starved of nitrogen. The structure of the soil gets unfavourable when the sugars decompose actively and this also affects the following crop. When a fallow comes in, the bacteria die and decompose, after the sugar in the soil is exhausted, when nitrogen is released again for the use of crops that are sown. The shortage of available nitrogen in the soil is a temporary phase only. When a legume is interposed, the depressing effect of sorghum is not felt by the crop following the legume. The injurious effects can be got over by applying a sufficient quantity of nitrogenous fertilizers to the succeeding crop.

Sorghum poisoning. Young sorghum plants and also ratoon sprouts from sorghum stubbles are poisonous and bring about the death of animals that graze them. These contain cyanogenetic glucoside, particularly in large quantities when the plants are stunted or when they are

affected by drought. The glucoside hydrolyses in the stomach of cattle and produces hydrocyanic acid. This is highly poisonous and brings about the death of the animals quickly. The glucoside content decreases as the sorghum plants make growth. Plants, which are more than 75 days old, are nearly free of the glucoside. Plants which have flowered may be said to be free of the glucoside and can be safely given as feed for cattle. Young growths can be dried or ensiled and used as feed for animals. These bring about the destruction of the glucoside in the young plant tissues.

A number of remedies have been tried for counteracting the sorghum poison. The following have been found to be useful, in some trials conducted in Australia. (1) Drenching cattle with a solution of photographic hypo, 2 ounces in a pint of water and repeating it every 3 hours, if necessary, (2) administering a teaspoonful of permanganate of potash and two pounds of glucose or molasses in a quart of water, and (3) drenching one quart of dilute molasses may be suggested as remedies. Hydrocyanic acid acts rapidly on the animal system and the antidote has to be administered swiftly, to be of any value.

VI. 3 - Cumbu (*Pennisetum typhoides* Stapf & Hubbard.)

Common names: English - pearl, bulrush or spiked millet; Tamil - cumbu; Malayalam - kambam; Telugu - sajja or ganti; Kannada - sajje; Hindi - bajra.

Distribution. *Cumbu* is the most important small millet grain used by a large section of the people in Asia and Africa, ranking in importance next to sorghum. It was cultivated in 28·82 million acres in the Indian Union during 1953 - '54, with 7·06 million acres in Bombay,

2·63 millions in Uttar Pradesh, 2·2 millions in East Punjab, 1·4 millions in Madras and 1·2 millions in Andhra States. The other States had less than one million acres each, individually. The total production of *cumbu* grain in India during the year was 42·46 lakhs tons, with an average yield of 350 lb. per acre.

The normal extent of its cultivation in the several districts of the Madras and Andhra States is given below:

Madras		Andhra	
District	Extent in acres	District	Extent in acres
Chingleput	11,910	Srikakulam } Visakhapatnam }	176,940
South Arcot	108,860		
North Arcot	66,920	East Godavari	44,730
Salem	203,820	West Godavari	6,980
Coimbatore	274,110	Krishna	10,957
Tiruchirapalli	220,480	Guntur	167,740
Tanjore	4,380	Kurnool	65,450
Madurai	46,360	Anantapur	108,100
Ramanathapuram	96,550	Cuddapah	99,510
Tirunelveli	154,990	Nellore	108,100
Malabar	30	Chittoor	130,930
South Kanara	—		
Nilgiris	10		
Total (Madras)	1,188,420	Total (Andhra)	1,177,520

Cumbu occupies 11·9 lakhs acres in Madras State and 11·9 lakhs acres in Andhra State, with 12·2 and 15·1 per cent of the extent respectively under irrigation. Coimbatore, Tiruchirapalli, Salem, Tirunelveli and South Arcot districts have large areas under the crop. Its cultivation is fairly spread out in Andhra State, with Krishna and West Godavari districts alone having small areas under the crop.

Adaptation. *Cumbu* is predominantly a crop of the light soils and regions of low rainfall. It comes up better than most other cereals in shallow gravelly soils. It is also grown in heavy black soils, as in Tirunelveli and Guntur districts. It is sown in June-July in the red soil areas with the onset of the south-west monsoon. Late sowings may be done up to August. The black soils are sown later, during October-November,when the north-east monsoon breaks out. Irrigated crops are usually sown in February and March.

The sowings in the different regions are so timed that there are sufficient rains during the period of growth of the crop and the weather is clear during the time of flowering. *Cumbu* is essentially a cross pollinated crop and rains during the period of flowering interfere with the setting of the grains.

Varieties. Two major types of *cumbu* are recognised. The type grown in dry lands has the glumes adhering to the threshed grain and has to be dehusked before consumption. It is called 'Kattu cumbu'. The type grown in garden lands threshes free of glumes and goes by the name of 'Arisi cumbu'. It is cultivated rarely in dry lands, as in parts of Tiruchirapalli, when it does not yield as much as 'Kattu cumbu'. Certain intermediate types have the glumes enclosing the grains partially.

There are 3 main varieties of dry land *cumbu*, differentiated by their duration. The short duration variety, called 'Arupatham cumbu', flowers in about 60 days and has a duration of 80 days. It is suitable for regions, where the seasonal rains are confined to a short period only. Where the rains are spread over a longer period, medium duration varieties maturing in 100 days or more are preferred. Long duration varieties are sown in regions, where the rains are distributed over a reasonably long period, with short spurts of rain off and on, interspersed by clear weather. The 'Perum cumbu' is a representative of this type and has a duration of more than 6 months. It is sown in July in the gravelly soils of Dharapuram and Erode of Coimbatore district. Fresh tillers spring up with each batch of rain and they produce ear heads serially, which mature at different times. The harvest is done periodically as the ears mature.

Plant characteristics. *Cumbu* is highly cross fertilised in a state of nature and lends itself for the production of hybrid seeds, capable of giving high yields. The choice of suitable parents, the maintenance of purity of the parental stock and their crossing require specialised technique. The purity of the parental strains is maintained by in-breeding at research stations. The best combining varieties are chosen, and their seeds are sown mixed together for the production of commercial hybrid seeds. The two strains get crossed in a state of nature and most seeds produced are hybrid seeds, which are issued to farmers for sowing. These produce vigorous crops and if the seeds produced by hybrid crops are sown, the resulting plants are not so vigorous as the original hybrid plants. Hybrid seeds have therefore to be secured from agricultural stations every year, for producing

vigorous crops, year after year. The technique used for producing hybrid *cumbu* seeds is slightly different from that used for maize, as *cumbu* is a hermaphrodite, while maize is monœcious. Mass hybridisation is therefore less complete in *cumbu* than in maize.

Rotations. *Cumbu* is grown in rotation with cotton and fodder sorghum in Tirunelveli district. Lands near the villages are sown to *cumbu* year after year and this is referred to as 'Cumbadi-cumbu'. In Ceded districts, *cumbu* is followed by *tenai, ragi,* castor or cotton. Horsegram follows *cumbu* at Coimbatore. In South Arcot, *cumbu, ragi,* groundnut, rice and sugarcane are grown in garden lands, in a three year rotation, one after another.

Mixtures. *Cumbu* in sown mixed with sorghum and redgram in Salem and North Arcot districts. *Gogu* (*Hibiscus cannabinus*) and sunhemp are sown mixed with *cumbu* at Guntur. Groundnut is inter-sown in the standing *cumbu* crop in South Arcot district at the time of hoeing. Greengram, dewgram and lablab are commonly mixed with *cumbu* in light soils.

Preparatory cultivation. The lands are ploughed 3 or 4 times and brought to good tilth. Lands devoted to *cumbu* year after year are prepared more thoroughly by ploughing 6 or 7 times. More attention is devoted to the preparation of the land for *cumbu* than for sorghum. *Cumbu* requires a finer seed-bed.

Manuring. Cattle manure is applied to dry land *cumbu* at 5 cart-loads an acre, when available. Otherwise, sheep are penned at about 1,000 per acre. 'Cumbadi-cumbu' lands are manured heavily at 8 to 10 cart-loads of cattle manure. In places like South Arcot, where cattle manure

cannot be spared for dry lands in sufficient quantities, available sweepings and farm refuse are applied. Garden land crops are given at least 10 cart-loads of cattle manure per acre.

Sowing. *Cumbu* seeds are broadcasted in Tamil Nad at 3 lb. per acre in black soils and at 8 to 10 lb. in other cases. This is a very heavy seed rate, as the seeds are small and 3 to 4 lb. may be ample, but provision is made for uncertain weather and soil conditions. In Ceded districts, 2 to 2½ lb. of seeds are drilled over an acre and the stand of the crop is quite satisfactory, in spite of what may appear a low seed rate. In Visakhapatnam district, where the rains are distributed properly, *cumbu* seedlings are raised in nurseries and they are transplanted 6 inches apart in alternate plough furrows, as with sorghum. The seedlings establish easily, when the transplantation is done in drizzly weather.

In garden lands, *cumbu* seeds are broadcasted, covered with light ploughs, and beds and channels are formed for irrigation. There is also the practice of raising nurseries and planting the *cumbu* seedlings during the summer months, after irrigating the beds. The seed rate used for broadcasting in garden lands is 4 to 6 lb. per acre.

After - cultivation. *Cumbu* fields are worked with light ploughs in dry lands in the Tirunelveli region, both length and breadth-wise when the crop is about 3 weeks old and there is sufficient moisture in the soil. The crops are thinned thereby and look like having been ploughed in, but recover remarkably well and make vigorous growth like transplanted crops and there is a full stand of the crop. The land is cleaned of weeds at the same time to a large extent and the crops tiller profusely

and do not have competition with weeds of the same age. In South Arcot district, the crop is hoed about 2 weeks after sowing and groundnut kernels are sown by dibbling in the interspaces at the time. Drilled crops are worked with blade harrows twice in the Ceded districts.

Harvesting and threshing. The ear heads mature uniformly in garden lands and they are gathered in one harvest. The ears mature at different times in dry lands and they are gathered in 2 harvests, usually. 'Perum cumbu' stands in the field for over 6 months and the harvest is done in 4 or 5 stages.

The ear heads are threshed immediately after harvest, when small in quantity. In other cases, they are dried and threshed under the feet of cattle leisurely, when convenient. The glumes and the thin papery chaff get detached from the ear-heads at the time of threshing and float about in the air. They irritate the skin of the people engaged in threshing, particularly about the region of the eye. The threshing is, therefore, done sometimes in dewy moon-lit nights, for reducing the discomfort. A small quantity of water is sprinkled over the ear-heads before threshing. It keeps down the floating chaff and discomfort to labourers is considerably reduced. The grains are winnowed, cleaned and dried before storage.

The straw is cut leisurely. It is extremely pithy and has a very low feeding value and is not used for feeding cattle ordinarily, except when there is extreme dearth of fodder. It is commonly used for thatching roof and as fuel.

Green fodder. *Cumbu* can be sown thick and cut when the ears are in the milk stage for use as green feed, like sorghum. The yield of green fodder *cumbu* is about 20,000

lb. per acre, when the crop is about 70 days old. The stubbles can be ratooned and one or two more cuttings taken in garden lands.

Yield. The yield of *cumbu* grain ranges from 300 to 700 lb. per acre in dry lands and 1,500 to 1,800 lb. in garden lands.

VI. 4—Ragi (*Eleusine coracana* Gaertn.)

Common names: English-finger millet; Tamil-keppai, kelvaragu, or ragi; Malayalam-muttari; Telugu-ragulu; Kannada-ragi; Hindi-ragi.

General features. *Ragi* is a cosmopolitan cereal grown in large areas all over the Indian Union in almost all seasons and types of soils. It is grown both under rain-fed and irrigated conditions. It is about the best of the millets from the point of palatability and food value. It is particularly rich in protein and calcium. It has the reputation of being a suitable food for diabetic people, on par with wheat. The grain keeps well in storage for a number of years without damage by insect pests and is much better than most other cereals in these respects. This may in part account for its popularity with farmers from the earlier years, when transport had not developed and surplus grain had to be kept over in storage as a reserve for tiding over lean years.

Distribution. The extent of cultivation and production of *ragi* in the several States in the Indian Union during the year 1952—'53 is furnished in the next page.

Ragi is an important crop in Mysore, Madras, Bombay, Bihar, Andhra, Orissa and Hyderabad States. It is grown in less than one lakh acres in each of the other States and is not important.

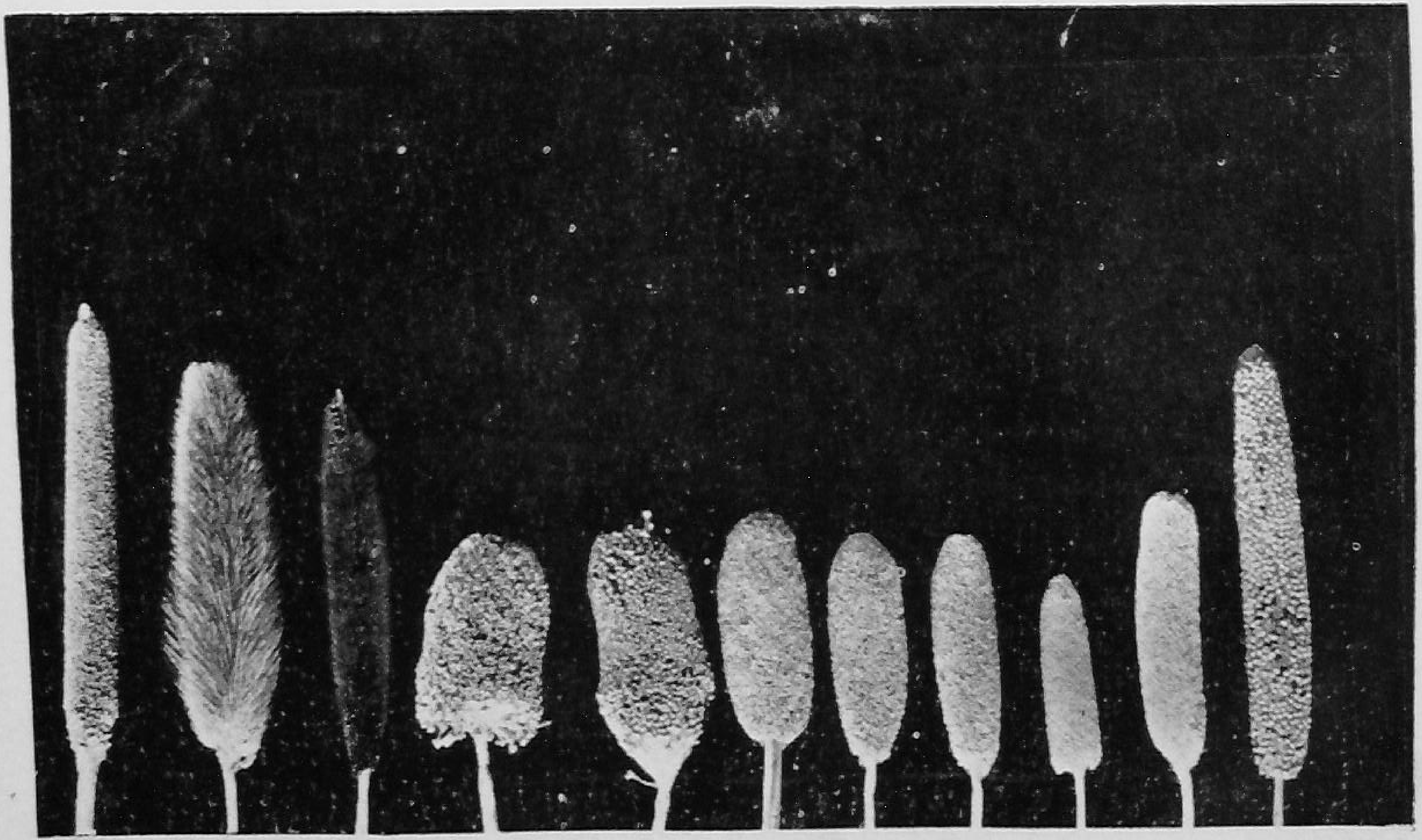

Fig. 21. Panicle shapes in cumbu.

—*Courtesy: Director of Agriculture, Madras.*

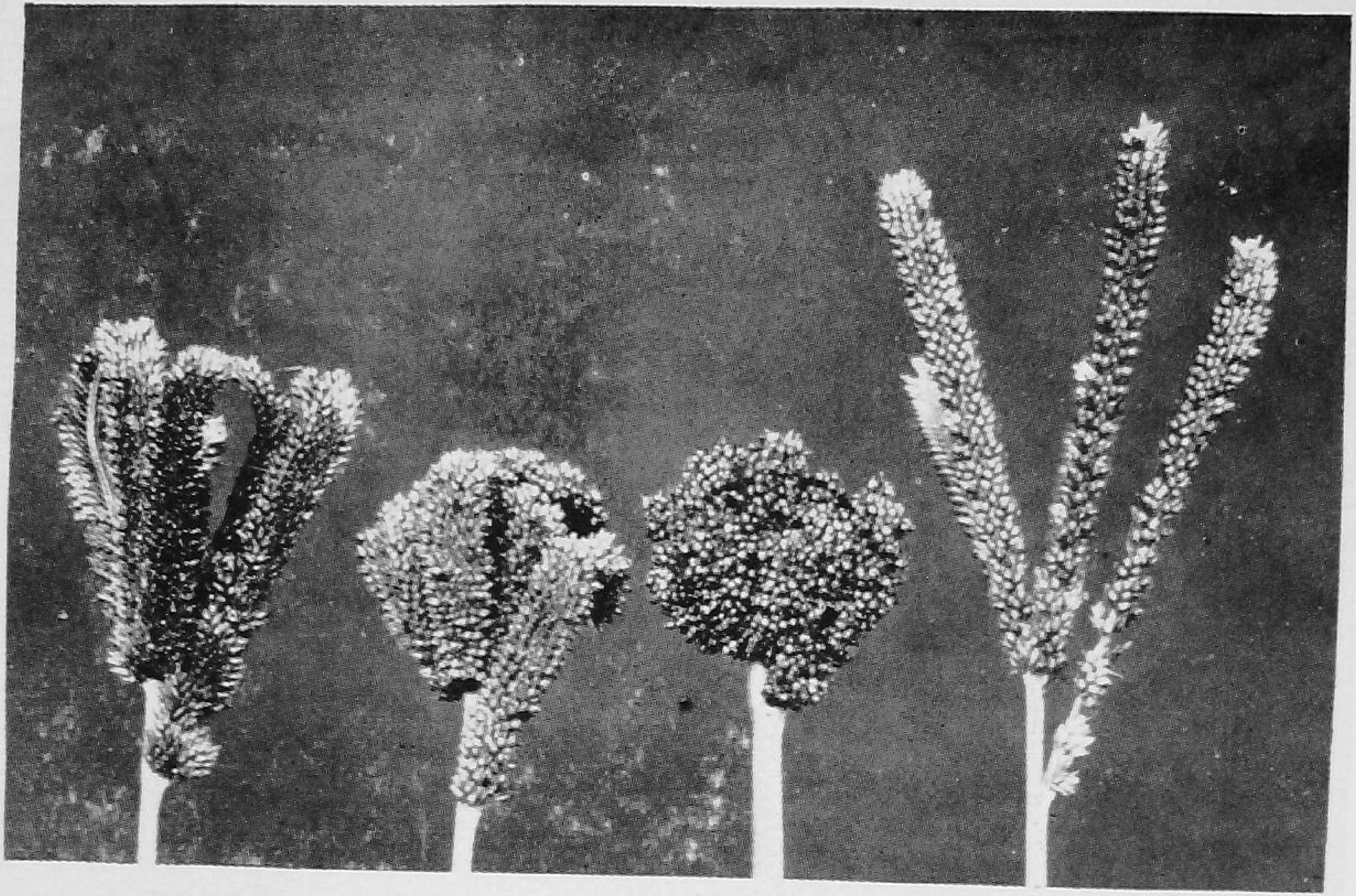

FIG. 22. Ear head types in ragi.

—*Courtesy:* *Director of Agriculture, Madras.*

Name of State	Area in 1,000 acres	Production of ragi grain in 1,000 tons.
Mysore	1,635	193
Madras	876	334
Bombay	692	197
Andhra	638	233
Bihar	528	106
Uttar Pradesh	464	87
Orissa	304	70
Hyderabad	140	16
Other States	111	29
Total India	5,388	1,235

Source : *Agrl. Situation in India,* June 1953, pp. 194 & 5.

The normal extent of cultivation of *ragi* in Madras and Andhra States is given below :

Madras		Andhra	
District	Extent in acres	District	Extent in acres
Chingleput	84,050	Srikakulam } Visakhapatnam }	189,540
South Arcot	75,520	East Godavari	16,360
North Arcot	95,680	West Godavari	4,270
Salem	266,950	Krishna	3,400
Coimbatore	134,550	Guntur	13,870
Tiruchirapalli	55,950	Kurnool	19,170
Tanjore	11,440	Anantapur	23,530
Madurai	47,340	Cuddapah	90,890
Ramanathapuram	65,460	Nellore	86,600
Tirunelveli	25,110	Chittoor	132,320
Malabar	4,490		
South Kanara	5,510		
Nilgiris	3,660		
Total (Madras)	875,710	Total (Andhra)	638,050

The cultivation of *ragi* is distributed fairly well all over the Madras and Andhra States. It is grown as a rain fed crop in fair areas in Srikakulam, Visakhapatnam, Chittoor and Salem districts, where the rains are favourably distributed; the crop is established during the south-west monsoon season and it makes good growth with the north-east monsoon rains. It is grown mostly as an irrigated crop in other districts. It is under stray cultivation in wet lands in rotation with rice as an irrigated crop, either in the early south-west monsoon season before rice, or as a summer crop from December onwards after the harvest of the rice crop. The irrigated crop occupies 56·3 per cent of the total extent under *ragi* in Andhra Desa and 47 percent in Tamil Nad.

Adaptation. *Ragi* requires a well distributed moderate rainfall and is not grown widely as a rain fed crop like other millets in South India. But in Mysore, where the climate is milder and the rainfall is more evenly distributed, it is grown in large areas as a dry crop, even where the rainfall is low and where it is considered to be a drought resistant crop. The mildness of the climate in the Mysore plateaux shifts the emphasis from the quantity of rainfall to the distribution of the rains, as a factor contributing to the production of *ragi* under rain-fed conditions. Light drizzles of rain received periodically during the growing period as in Mysore, the Nilgiris, North Salem, Srikakulam, Visakhapatnam and Chittoor appear to be particularly suitable and conducive to the proper growth of the crop. In a similar way, *ragi* requires light irrigations at frequent intervals in garden lands. It is the only cereal which thrives equally well both in the warm plains and in the cold hilly regions.

Season. *Ragi* is grown in the hills at Ootacamund and Coonoor, at altitudes up to 7,000 feet above sea level, between May and September and almost all through the year in the other parts of the Madras and Andhra States. The periodical sowings of *ragi* done at the Millet Breeding Station, Coimbatore, indicate that,

1. the crop does not fail completely in any season of the year, though it does better in some seasons than in others,

2. short duration varieties do well during the south-west monsoon season, when planted early in June and long duration varieties do well when planted after July,

3. the summer crop can be raised successfully from December onwards, the greater the delay in planting *ragi* beyond December, the longer is the duration of the resulting crop, and

4. the yield varies to a greater extent in the summer crop than in the main season crop planted in June-July.

Soils. *Ragi* is grown in all types of soils and has a wide range of adaptability. It does well in the rich loamy soils of the Nilgiris, in the sandy loams of South Arcot, Salem and Mysore, and in the black cotton soils of Tirunelveli and Mysore. It is also grown in alkaline soils and it tolerates alkalinity better than most crops.

Varieties. Each district has its own local varieties of *ragi* and these can be roughly divided into two main groups, depending upon the formation of the ear heads, as a closed fist-like type or an open type with the fingers of the ear head spread out. The closed type is more commonly grown and goes by the name of 'Suruttai', that is, incurved. The open type is called 'Thalai

virichan'. Sub classification of the varieties is based on their duration as long and short duration varieties, like 'Perum ragi' and 'Gidda ragi' and also on their pigmentation like 'Vellai suruttai' (white incurved) and 'Karun suruttai, (black incurved).

Rotations and mixtures. The following rotations are commonly in vogue in South India:

(*a*) garden lands—

1. *ragi*, tobacco and sorghum in 1 year, or
2. *ragi*, tobacco, sorghum and Cambodia cotton in a period of 2 years and,

(*b*) wet lands—

1. *ragi* (May to August) and rice (September to January or
2. rice (August to December) and *ragi* (January to April).

In the uplands of Mysore, *ragi* is rotated with groundnut. *Ragi* follows *cumbu* in Tirunelveli, and gingelly, castor, cotton and *tenai* in Cuddapah and Kurnool.

Ragi is grown mixed commonly with lablab in Mysore, Salem and Coimbatore under rain fed conditions. Niger, redgram, cow pea and sorghum are sown in lines along with *ragi* in Mysore occasionally. In South Arcot, groundnut is intersown in *ragi* fields at the time of hoeing. In Visakhapatnam, greengram is broadcasted and while covering the seeds, *ragi* seedlings are transplanted in plough furrows, as with sorghum.

Preparatory cultivation. The fields are ploughed 2 or 3 times after the harvest of the previous crop, and cattle

manure, compost, municipal rubbish and tank silt are applied liberally, before the last ploughing. Cattle manure is applied up to 40 cart-loads per acre, or municipal compost up to 60 cart-loads per acre at Coimbatore, and the other crops that come in the rotation, inclusive of commercial crops like tobacco, are not manured. In other places, 10 to 15 cart-loads of cattle manure are applied to an acre, and when it is limited, sheep are penned at 1,500 to 2,000 sheep per acre as a supplement. Cow pea or sunhemp is grown in May and ploughed in as green manure in parts of Mysore, for the late season *ragi* crop and treated as the equivalent of 6 to 10 cart-loads of cattle manure per acre.

Sowing. This is done in various ways. In dry lands *ragi* seeds are broadcasted at 8 to 10 lb. to the acre, covered with light wooden ploughs and levelled by working brush harrows across the furrows. In mixed cropping, the other seeds are sown in plough furrows, 6 to 8 feet apart, at the time of covering the seeds. *Ragi* is more commonly sown with 6 or 12 tined drills in Mysore; the tines are 10 and 6 inches apart respectively. Lablab is sown in every 12th row. High seed rates up to 25 lb. of *ragi* and 15 lb. of lablab per acre are adopted. The heavy seeding makes allowance for possible low germination of the seeds and the heavy thinning to which the crop is subject during intercultivation. In Visakhapatnam and Salem, *ragi* seedlings are transplanted in plough furrows during drizzly weather. In garden lands, *ragi* seedlings are transplanted in beds after irrigation, as with sorghum and other crops.

Ragi nurseries. *Ragi* seedlings are raised in specially prepared seed-beds. The selected area is ploughed repea-

tedly, brought to good tilth and manured with cattle manure at 20 cart-loads per acre. The land is finally laid into long narrow beds, which facilitate weeding being done later, if necessary, from the bunds without trampling the beds. The seeds are broadcasted at 1 lb. per cent of nursery area and covered lightly by raking with fingers. The seeds are sometimes covered by spreading a thin layer of powdery cattle manure or wood ash. This keeps the surface soil loose and seedlings can then be lifted without much damage to roots. The nursery is irrigated immediately after sowing and later at intervals of 3 or 4 days, as and when necessary. The seedlings remain in a condition fit for planting for about a week from the 20th day. When the seedlings are kept longer in the nursery, they develop nodes and get unfit for planting. Nurseries have therefore to be sown in stages, where large areas are cultivated and transplantation tends to get protracted. Seedlings from 2½ to 3 cents of nursery will be required for transplanting an acre.

Transplantation. In dry lands, seedlings are dropped in plough furrows and made to rest on the sloping sides, during drizzly weather, when they get established readily. If the weather clears after transplantation and becomes hot, all the seedlings do not establish and gaps are caused.

In garden lands, water is let into the beds and the seedlings are transplanted before the irrigation water is completely absorbed by the soil. In the heavy soils of Anakapalli, transplantation is done 6 hours after irrigation, allowing the soil to get soaked completely, and become soft and loose. The seedlings are transplanted singly, 5 to 6 inches apart in the beds and on one side of

the irrigation channels. Life-irrigation is given on the third day.

After-cultivation. Irrigated *ragi* crops are hand-hoed after about 20 days of planting. The weeds are uprooted and allowed to dry up before the next irrigation. If the fields are very weedy, they are weeded again 3 weeks later and this may not be ordinarily necessary, as the crop tillers, covers the ground fairly well and keeps the weeds in check.

In dry lands, the crops are thinned when they are 6 to 8 inches high. Bullock hoes, called 'kuntes', are worked in Mysore, both along and across the fields, which removes the weeds and thins the crop to the extent necessary, both in drilled and broadcasted crops. A hand hoeing is sometimes given for removal of weeds, if necessary.

Irrigation. *Ragi* requires light irrigations at frequent intervals and 10 to 13 irrigations may normally be required, when timely rains are not received. Irrigations are given once in 7 to 10 days, with about 2 inches depth of water each time. The duty of water for *ragi* is about 25 acre-inches, inclusive of rainfall during the crop period.

Harvest. Irrigated *ragi* crops tiller freely and the tillers do not produce ear heads uniformly. The ripe ears, which are yellow or brown alone, are gathered at the time of the harvest. The ears are gathered twice normally, and rarely thrice when the crop is very vigorous. If the ears are not gathered as they mature, the ripe grains are shed in the field. When there are continuous rains, the mature grains germinate in the ear head itself and there may be considerable loss. These emphasise the need for more than a single harvest of the *ragi*

ears. During the final harvest, mature and immature ears are gathered completely and the grains obtained from these ear-heads are not suitable for seed.

Dry crops do not tiller much and the ear-heads mature more or less uniformly. The entire crop is cut with the stalk, dried and threshed under the feet of cattle.

After gathering the ear heads in garden lands, the stalks are kept on the land and cut in small quantities each day to serve as green feed for cattle. When the stalks turn yellow, they are cut, dried and stacked for use as feed later. The dry straw is tough, fibrous and poor in quality; it is not relished by cattle so well as other straws. It improves on stacking. Fermentation takes place in the stack and the straw gets less tough, and more palatable. The dry straw produced in dry lands is, on the other hand, of good quality and is readily consumed by cattle. It is an important fodder in Mysore, where it is considered to be superior to sorghum straw.

Green *ragi* straw can be ensiled, particularly when the harvest is in the rainy season. Silo pits are dug in elevated places, which are not subject to stagnation of water. The pits can be 6 feet deep and 6 feet wide, with a length of about 5 feet for every acre of the crop. The green straw is packed tightly in the pit, trodden well by men for compacting it and carried to a height of 3 feet above ground level. The top is given a dome shape to shed rains and covered with a thick layer of soil, for excluding air from the material. It sinks a little in about a month and cracks develop on the soil cover, which are closed by plastering with wet mud. The green straw undergoes fermentation in the silo pit and turns light

brown and the fermented material is called 'silage'. It can be used for feeding stock, two months after pitting or later. It can be kept in the pit for about a year. A layer of straw at the top, sides and the bottom of the pit contacting the soil, gets decomposed and becomes unfit for feeding. The wastage may amount to 20 to 30 per cent, depending upon the material, the closeness of packing, the size of the pit and the period of storage.

Ragi silage has a sweet smell and it is consumed by cattle with relish. Cattle do not reject any part of the silage. Ensiling can be done with *ragi* straw harvested during rainy weather, which cannot be conserved in any other way. There is loss of dry matter, carbohydrates and protein during storage, which is unavoidable and which is not more than what is caused by attempting to conserve the straw by drying during unfavourable rainy weather.

Threshing. The harvested ear heads are in different stages of maturity. Some are green, some brown and dry and the rest are midway between the two. They are kept heaped and covered with green ragi straw for a period of 3 to 5 days, when they undergo slight fermentation. There is rise of temperature inside the heap and all the ear-heads turn brown. The period of fermentation has to be varied with the stage of ripeness of the ear-heads. Ears gathered during rainy weather and immature grains have considerable moisture and tend to ferment quickly. Dry and mature ears do not ferment to the same extent or so easily, and they are kept in the heap for a longer period. The fermented ears are spread out on the threshing floor, dried in the sun and threshed under the feet of cattle or with stone rollers. Small

quantities of selected mature ear heads are dried without any preliminary fermentation, threshed and reserved for seed. They are light brown in colour.

The fermented grains are of a very dark brown colour, or even black sometimes. They have undergone a kind of curing and get fit for consumption earlier than unfermented grains. Fresh *ragi* grain sets up digestive disturbances and is not suitable for consumption, immediately after threshing. It is kept in storage for some months, before it is used as food.

Yield. Irrigated crops yield 2,000 to 3,000 lb. of grain and 8,000 to 12,000 lb. of green straw or 3,000 to 5,000 lb. of dry straw per acre. Rain-fed crops give 500 to 1,000 lb. of grain and 1,000 to 1,500 lb. of dry straw per acre.

VI. 5 - Tenai (*Setaria italica* Beauv.)

Common names: English - Italian or fox tail millet; Tamil - tenai; Malayalam - tena; Telugu - korra; Kannada-navanne; Hindi - kangoone.

Adaptation. *Tenai* is called the 'fox tail millet' popularly, as its bent bristly ear heads resemble the tail of the fox in a way. It is a minor rain-fed millet crop, that comes up well in regions having 20 to 30 inches of annual rainfall. It can be raised successfully even where the seasonal rains are limited to a short period of about 2 months, as in the Ceded districts. Its cultivation is thus concentrated in Bellary, Kurnool, Anantapur and Cuddapah districts, which have 1·4 million acres under the crop. It occupies 32·7, 32·3, 27·0, and 16·3 per cent of the total extent under cereals respectively in these districts. The crop comes to maturity and ves some

yield, even when there are some rains at the time of sowing and in the early stages of growth. This is an important factor influencing the preference shown to *tenai* in this region, where the rainfall is uncertain, both in quantity and distribution.

It has a cosmopolitan habit, with limited requirements with regard to soil, climate and location. It is hence grown over large parts of Asia and Africa and in small areas in Southern Europe and North America. It is even grown in low elevations at the foot of the Himalayas.

Tenai is grown in both red and black soils under rain-fed conditions. It is sown in June-July in the red soils with the commencement of the south-west monsoon and in September-October in black soil areas with the onset of the north-east monsoon. It is grown in red loamy soils under irrigation as a hot weather crop from January to April.

The normal extent of the cultivation of *tenai* in Madras and Andhra States is given in page ,176, district-wise. Kurnool, Anantapur, Cuddapah and Guntur districts have large areas under *tenai* and other districts have negligible areas only. It occupies 78 thousand acres in Madras and 14·5 lakhs acres in Andhra, with 28,820 and 52,700 acres respectively under irrigation, representing 36·8 and 3·6 per cent of the total area under the crop.

Varieties. There are a number of local varieties in the several regions and they take their name after the colour of the grains as 'Sen tenai' (red), 'Karun tenai' (black) and so forth. Some varieties have bristles on the ear-heads. In certain varieties, the grains are borne on

Madras District	Extent in acres	Andhra District	Extent in acres
Chingleput	1,500	Srikakalam } Visakhapatnam }	12,160
South Arcot	11,590		
North Arcot	1,780	East Godavari	3,650
Salem	14,960	West Godavari	530
Coimbatore	27,850	Krishna	770
Tiruchirapalli	790	Guntur	63,560
Tanjore	40	Kurnool	423,160
Madurai	11,520	Anantapur	324,270
Ramanathapuram	6,200	Cuddapah	108,890
Tirunelveli	230	Nellore	33,700
Malabar	1,290	Chittoor	3,170
Nilgiris	240		
Total (Madras)	78,370	Total (Andhra)	1,453,220

subsidiary rachis branching off from the main stalk on either side, giving the appearance of pleated rows of grain, commonly known as 'Sadai tenai' and 'Jada korra'. Irrigated varieties are mostly of this type.

Rotations and mixtures. *Tenai* is grown as a pure crop only in garden lands. It is mixed with many other crops in dry lands, though occasionally it may be grown as a pure crop. But there are no specific rotations. Cotton and *tenai* are a favourite mixture, both in Tamil Nad and Andhra Desa. *Korra-pathi,* or *tenai*-cotton

mixture is sown in alternate years in the Ceded districts followed by sorghum. In parts of Bellary, *tenai* is sown as a pure crop in July and when it is in the flowering stage, 'Thella jonna', the main sorghum variety of Bellary, is sown in plough furrows opened in between the *tenai* rows. If 'Thella jonna' is sown earlier in the season, it does not set seed. Inter-sowing groundnut at the time of hoeing the *tenai* crop is a common practice in South Arcot district.

Cultivation. The land is prepared by working ploughs or blade harrows 2 or 3 times. *Tenai* seeds are broadcasted in Tamil Nad and drilled in Andhra Desa. Six tined drills are commonly used for drilling *korra-pathi* mixture in the Ceded districts, after blocking the holes in the hopper which feed the second and fifth rows. *Tenai* is fed to the other tines through the seed hopper. Cotton is sown with seed-tubes called 'akkadis', attached to the second and fifth tines. This gives one row of cotton alternating with two rows of *tenai*. The seed rate used is 5 to 7 lb. of tenai per acre for pure crops and 3 to 5 lb. for mixed crops. The broadcast crops are given a hoeing and weeding when they are 3 weeks old, and the drilled crops are worked with blade harrows once, in between the crop rows. The crop is not given any other cultivation.

The crop flowers in 60 to 70 days and is ready for harvest in 80 to 90 days, depending upon the variety. The mature crop is uniform in height, with golden yellow ear-heads of about the same size and is very attractive in appearance. This uniformity of the crop and of the ear-heads is rarely seen in other rain-fed crops. The entire crop is cut and threshed under the feet of cattle. The normal yield of *tenai* is 1,000 lb. of grain per acre in

garden lands and about 400 lb. in dry lands. The straw yield ranges from 500 to 1,500 lb. per acre.

Tenai grain is a good cereal food, which is relished by people. It keeps well in storage without damage by insects and is consequently a good famine reserve grain. The straw is thin and leafy and is liked by cattle. It is not given to cows, as it tends to reduce the secretion of milk in lactating animals and to induce abortion in pregnant cows.

VI. 6 – Varagu (*Paspalum scrobiculatum* Linn.).

Common names: English - kodo millet; Tamil - varagu; Telugu - arikalu; Kannada - harika; Hindi - kodra;

Varagu is a millet of minor importance and it occupies about 622,000 acres in Madras State and 326,000 acres in Andhra state, of which 32,000 and 3,700 acres respectively are under irrigation, representating 6·4 and 1·2 per cent of the total area under the crop. Tiruchirapalli, South Arcot and Nellore have each over one lakh acres; Kurnool, Salem, Ramanathapuram, North Arcot and Madurai have each 50 to 75 thousand acres, with small areas in other districts.

Varagu grain is of very poor quality, but it keeps well in storage and is not subject to insect damage. Immature grains and husk, as well as the ripening crops are poisonous. The mature grain is perfectly safe for consumption, after storage for some time. The straw is inferior in quality and is consigned to the manure pit or used for roofing.

Varagu is a hardy crop which comes up well even in poor soils, where other cereals cannot be raised

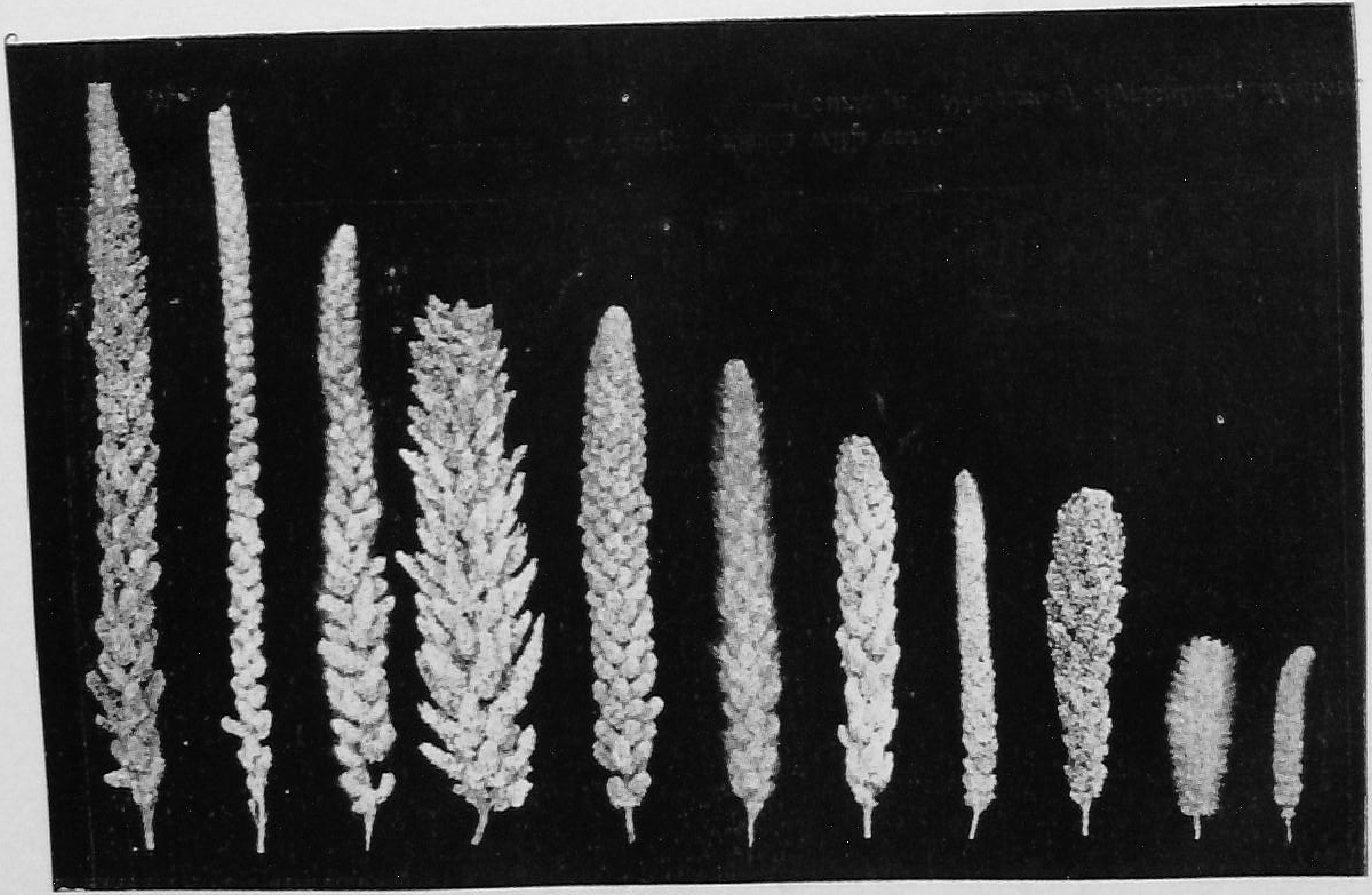

FIG. 23. Ear head shapes in tenai.

—*Courtesy* : *Director of* ***Agriculture, Madras.***

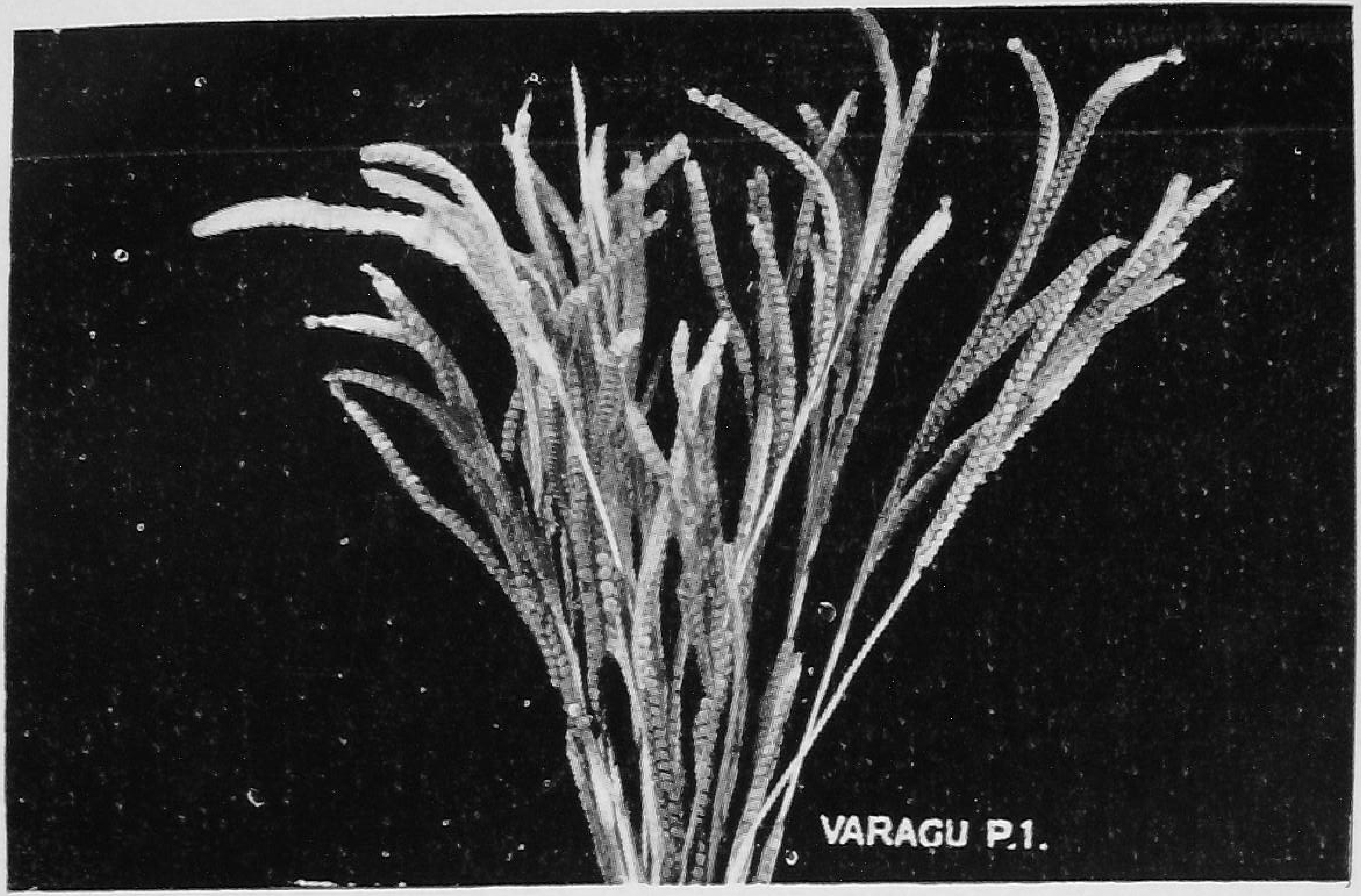

Fig. 24. A varagu branch with ears.

—*Courtesy: Director of Agriculture, Madras.*

economically. It resists drought and alkalinity of the soil to a remarkable extent and better than most crops. It has a duration of about 6 months and grows to a height of 2 to 2½ feet. It is sown in June-July with the early rains either as a pure crop, or mixed with redgram. The seed rate ranges from 10 to 20 lb. to an acre. The entire crop is cut and threshed under the feet of cattle. The husk is persistent, brown in colour and accounts for 40 per cent of the weight of the grain. The grain is smeared with red earth paste, dried in the sun and dehusked in small stone mills at home. The rice obtained by dehusking is white in colour.

The standard yield of *varagu* grain is 673 lb. per acre for the Andhra State and 832 lb. for the Madras State. Heavy yields are obtained from black soils. The straw yield ranges from 1,000 to 2,000 lb. per acre.

VI. 7—Samai (*Panicum miliare* Lam.)

Common names: English—little millet; Tamil—samai; Malayalam—shama; Telugu—samulu; Kannada—save; Hindi—shavan.

Importance. *Samai* is an important crop to the small peasant in regions of low fertility, as it comes up fairly well even in poor soils, where crops other than horsegram and castor cannot be grown successfully. The fertility of the land, the land tax for this class of land and the cost of cultivation are all so low that the peasants do not lose heavily even when the crop fails. Naturally, the yield of *samai* is also low. It is a poor man's crop and not important otherwise. It is the smallest of the millets.

Distribution. Samai is cultivated throughout India, Ceylon and other tropical countries and to a certain extent in the subtropics also. It is cultivated on the Nilgiris up to an altitude of 7,000 feet above sea level.

It occupies an area of 360,000 acres in Madras and 120,000 acres in Andhra State, more or less as a dry crop, with 138,000 acres in Salem, 74,000 acres in Coimbatore, 56,000 acres in Madurai, 32,000 acres in North Arcot, 24,000 acres in Tirunelveli, 60,000 acres in Anantapur and 11 to 12 thousand acres each in Srikakulam, Visakhapatnam and Chittoor districts. The extent of its cultivation in other districts is negligible. It is under irrigation in 4·4 and 1·1 per cent respectively of the extent under the crop in Madras and Andhra States.

Varieties. There are a number of varieties of *samai* of local importance in the several districts, differing in their duration, pigmentation of the grain, shape of the panicle etc. There are 2 definite groups, one with a duration of 3 months and the other with $4\frac{1}{2}$ to 5 months duration.

Season. The cultivation of *samai* is confined to poor, light, red soils, which are entirely rainfed. On receipt of rains facilitating sowing, the better classes of soils are taken up for sowing and *samai* is sown in the poor soils finally. The sowing may be done in June-July, or even early in August, though sowings are also done at other times, now and then. It is sometimes sown in summer, when adequate rains are received.

Rotations. There is very little scope for adopting rotations in the poor soils devoted to *samai*. Most crops

do not come up in such soils. Horsegram and *samai* are grown in alternate years in the poor red soils of Anantapur with castor also coming in once in a way. In parts of Salem favoured by both the south-west and the north-east monsoons, *samai* is sown with the south-west monsoon rains and horsegram with the north-east monsoon rains. It is grown in rotation with potato in the Nilgiris and with *modan* rice and ginger in Malabar.

Samai : is also sown mixed as a subsidiary crop with cereals like *cumbu*, *varagu* and *ragi*, pulses like horsegram, blackgram and lablab and occasionally with oil seeds like gingelly, castor and mustard.

Cultivation. The land is ploughed 2 or 3 times and *samai* is broadcasted in June-July and covered by ploughing. The fields are sometimes levelled with brush harrow or levelling board after sowing. Eight to ten pounds of seed are used for sowing an acre. No manuring is done. One hoeing and weeding complete the cultivation operations. The crop is cut when ripe, tied into small bundles, allowed to get dry and is later threshed under the feet of cattle. The yield ranges from 200 to 500 lb. of grain and 700 to 1,000 lb. of straw per acre.

The grain is dehusked and cooked like rice. The husk is 30 to 35 per cent of the weight of the entire grain. The grain is sometimes par-boiled like rice, before dehusking. It is also made into flour for making pancakes. The grain is not tasty and is seldom preferred, when other grains are available. The straw is of poor quality but cattle relish it and consume it readily. It is considered to be very poor in North India and is consigned to the manure pit.

VI. 8—Panivaragu (*Panicum miliaceum* Linn.)

Vernacular names : Tamil—kadaikanni, or panivaragu; Telugu—varigalu ; Kannada—baragu; Hindi—barri.

Habit. *Panivaragu* is a cold weather crop, grown during the dewy season. It is sown as the late season (*pyru*) crop in Andhra Desa and as a cold weather crop in Tamil Nad, being practically the last crop to be sown in dry lands during the year. It is also grown under irrigation during the same season or a little later. It has a duration of about 70 days and fits in as a catch crop after the harvest of the main crops of the season. Shortage of rainfall and moisture do not affect the crop seriously, as it matures quickly. It is, therefore, the poor man's favourite crop and is his stand-by in times of scarcity of rains.

Distribution. *Panivaragu* is one of the few millets that is cultivated all over the tropics and the subtropics. It is an important crop only in Guntur (291,000 acres) and Kurnool (83,000 acres). It is grown in about 2,000 acres alone in the rest of the Andhra Desa and in about 13,000 acres in Tamil Nad.

Cultivation. The land is ploughed 2 or 3 times and the seeds are broadcasted at 8 to 10 lb. to an acre. The irrigated crops are manured with 5 to 10 cart-loads of cattle manure to an acre. One hoeing is given when the crop is 20 days old. The crop is harvested before it is fully ripe and dry, to prevent the shedding of the ripe grains and threshed by treading with cattle. The yield of grain ranges from 250 to 500 lb. per acre under dry conditions and 1,000 to 1,500 lb. under irrigation. In the rich black soils of Guntur, the yield goes up to even 2,000

FIG. 25. A panivaragu plant and floral parts.
—*Courtesy: Director of Agriculture, Madras.*

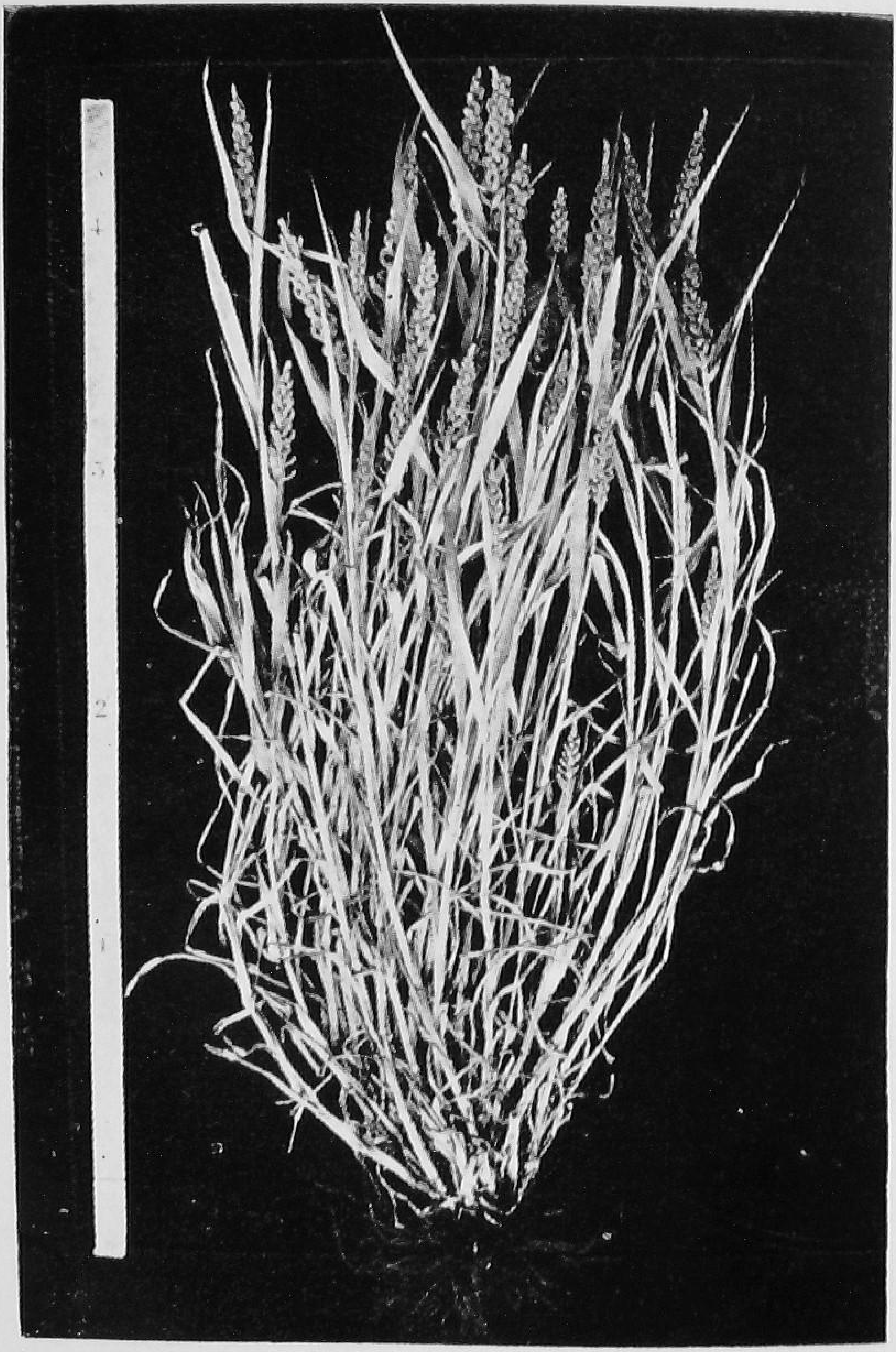

FIG. 26. A Kudiraivalli plant.

—*Courtesy: Director of Agriculture, Madras.*

lb. in years of favourable rains. The straw yield is nearly the same as that of the grain and it is considered to be a good fodder.

The grain is enclosed in husk, which is 30 per cent of the weight of the entire grain. It is dehusked and cooked like rice.

Panivaragu is grown as a forage crop in America and the grain is used for feeding hogs and poultry. The grain is rich in protein like wheat.

VI. 9 - Kudiraivalli (*Echinochloa frumentacea* Link.)

Common names: English - barn yard millet; Tamil - kudiraivalli ; Telugu - uddalu; Hindi - sanwak.

Kudiraivalli is a millet of minor importance, being grown in small areas here and there. It is grown as a rain-fed crop mostly, mixed with sorghum or maize, in light sandy soils, in low rainfall regions, as well as in low lands liable to stagnation of water, river banks and *lankas*. It is not usually manured.

It is grown in about 163,000 acres in the black soil tract of Madurai, Ramanathapuram and Tirunelveli, 24,000 acres in Srikakulam, 10,000 acres in Coimbatore-Salem tract and in negligible areas in other places.

Kudiraivalli plants are green in colour like other plants or purplish green. They tiller freely when soil and moisture conditions are favourable. The ear-heads are compact, semi-compact or even open. The grain is enclosed by husk, which is 35 percent of the weight of the entire grain.

The crop is sown in July ordinarily and comes to harvest in October and has a duration of $3\frac{1}{2}$ to 4 months. The seeds are broadcasted at 6 to 10 lb. to an acre or drilled with 5 to 6 lb. The crop yields 400 to 500 lb. of grain and 1,000 to 1,500 lb. of straw. Both the grain and straw are of poor quality.

There are certain perennial fodder varieties, which are cultivated like Guinea grass and give 6 to 8 cuttings of green fodder during the course of the year, with a total yield of 10 to 12 tons of green fodder per acre. Several allied species of *Echinochloa* are persistent weeds in wet lands.

VI. 10 - Maize (*Zea mays* Linn.)

Vernacular names. Tamil - muthu, makka or thuluka cholam; Telugu - mokka jonna;, Kannada - muskin jola; Hindi - bara jowar.

Maize is a native of Central America and has spread to the other countries of the world. It was introduced into India by the early Portugese settlers. It is commonly referred to as the 'American corn' on account of its origin, 'Indian corn' being the staple food of the Red Indians in America, or simply as 'Corn'. The maize flour goes by the name of 'American flour' and 'corn flour'.

Distribution. Maize has a wide distribution all over the world. It occupies an area of 46,580 acres in Andhra State, mostly as a rainfed crop and 11,000 acres in Madras State as an irrigated crop. The normal distribution of Maize in the two States is as follows:

Madras		Andhra	
District	Extent in acres	District	Extent in acres
Chingleput	30	Srikakulam }	2,980
South Arcot	180	Visakhapatnam }	
North Arcot	630	East Godavari	3,280
Salem	1,020	West Godavari	11,350
Coimbatore	330	Krishna	6,500
Tiruchirapalli	2,230	Guntur	18,390
Tanjore	6,150	Kurnool	3,200
Madurai	390	Anantapur	80
Malabar	120	Cuddapah	100
Nilgiris	10	Nellore	290
		Chittoor	410
Total (Madras)	11,090	Total (Andhra)	46,580

Maize occupies small areas only in most districts and and is of some importance in Guntur, Krishna, East Godavari, Visakhapatnam, Tanjore and Tiruchirapalli districts alone. It is cultivated as a grain crop in Guntur, Krishna and East Godavari districts, where it is used as a staple food grain like sorghum and mainly as a cob crop in the other districts. The maize ear-heads are called 'cobs'. Green cobs are produced for sale all through the year in Visakhapatnam. Maize is used as a food grain and as a stock feed in other countries. It is

also used for the manufacture of starch, glucose, dextrin and gums.

Adaptation. Maize can be grown all over the year, but it comes up best during the cooler months of the year in South India, with the sowing done from October to December. It requires a rich soil and comes up very well in the black loamy soils of Guntur and the Krishna *lankas.* It makes a heavy demand on soil moisture, particularly during the period of active growth and any shortage of moisture at this period tells on the final yield.

Varieties. Maize types are classified as follows:

1. **Dent corn** (*Zea mays indendata* Bailey.) The grains are long and angular, with a pit or groove at the top. This is the most common type grown in U. S. A.

2. **Soft corn** (*Z. m. amylacea* Sturter.) The grains are smooth.

3. **Flint corn** (*Z. m. indurata* Bailey.) The grains are smooth and the endosperm is hard and flinty and this is the type commonly grown in India.

4. **Pop corn** (*Z. m. everta* Sturter.) The endosperm is horny and the grains pop well, on being roasted. The ears and grains are small in size and the grains are pointed.

5. **Pod corn** (*Z.m. tunicata*). The individual seeds are enclosed in a husk-like covering. This is a primitive type.

6. **Sweet or sugar corn** (*Z. m. saccharata* Sturter.) The grains are translucent, wrinkled and sweet to taste. This is preferred to others for eating as green cobs and is classed as 'table corn', while others are called 'field corn'.

Rotations and mixtures. Maize is planted during the cold weather in place of *panivaragu* in the common rotation of *panivaragu,* chilli and tobacco in the Guntur district. It also takes the place of sorghum in the existing rotation or cropping in other districts. It is often grown mixed with turmeric at Salem.

Cultivation. The land is brought to good tilth and cattle manure is applied at 10 cart-loads per acre, before the last ploughing. After the soil is sufficiently moistened by the south-west monsoon rains in July, maize seeds are sown in plough furrows, spaced 2 feet apart, in dry lands. In garden lands, ridges and furrows are formed 2 to 2½ feet apart and 2 or 3 seeds are dibbled 6 inches apart on the side of the ridges. The plants are thinned later, leaving 1½ to 2 feet between adjacent plants in the rows. The crop is hoed, weeded once or twice and earthed up a little, when there is a tendency to lodge. It gets ready for harvest in 110 to 120 days.

Harvesting. As the maize ear-heads mature, the leaves turn yellow and the bracts enclosing them begin to dry up. They are then picked from the plants and dried after peeling the bracts. The grain is separated from the cobs by flailing with bent sticks or by treading with cattle. Big sized cobs are kept with the enclosing bracts for the next season's seed. The retention of the bracts prevents weevil damage, which is particularly severe with maize, as with sorghum.

Yield. The normal yield of maize is 1,000 to 1,500 lb. of grain and 2,000 to 3,000 lb. of straw per acre, in dry lands. In garden lands, the yield of grain is 2,000 to 3,000 lb. of grain and 4,000 to 6,000 lb. of straw. The green plants left behind after the removal of cobs are cut

in stages and used as green feed for cattle. They are sweet to taste and are relished by stock.

Hybrid maize. In cereals, the growing shoot terminates in a flower cluster, which forms the earhead. The flowers are bi-sexual and pollen from the same plant fertilises the pistil which develops into the grain eventually. Maize is an exception. The panicle formed at the terminal end of the shoot bears male flowers only and it is called the 'tassel'. The ear-heads are formed in the lower leaf axils and carry the female flowers attached to a thick peduncle in a regular fashion, forming a number of vertical rows. These ears are called 'cobs' and are enclosed by a number of bracts, which are tough and leathery. Each plant bears one or two cobs. The pollen grains shed by the tassels are carried by wind and do not ordinarily become available for fertilising the cobs on the same plant, though it is not completely ruled out. They fertilise the cobs on other plants. Maize is thus essentially a cross pollinated plant.

The maintenance of purity of the types and varieties of maize is very difficult, as it is cross pollinated. Naturally, there is considerable variation from generation to generation. The purity of specially selected parent material can be maintained by resorting to artificial self-pollination, that is, by using the pollen from the same plant for fertilisation. The cobs are enclosed in paper bags for the purpose and pollen from other plants is thus excluded. Pollen is collected from the tassels and dusted over the cobs of the same plant, when the stigma is receptive, after removing the paper bags. The bags are replaced after dusting the pollen. This is repeated for 3 or 4 days, till all the pistils on each cob are fertilised.

A number of valuable lines of maize are maintained in this manner in American Research Stations, by selfing each generation of plants. Plants, which do not breed true and show characters other than those for which they were selected originally, are pulled out and this is called 'purification'. When selfing and purification are carried on for a few generations continuously, the plants breed true to type for the selected characters. They are then referred to as 'pure lines' or 'in-bred lines'. For producing hybrid seeds, two chosen pure lines are planted side by side. The mother line is de-tasseled and it gets pollinated only by the male line on its side. The seeds produced on the mother line plants are all crosses and when they are sown, the plants produced grow vigorously and give increased yields of grain and straw. The extra vigour of the hybrid generation of plants is referred to as 'hybrid vigour'. On a field scale, the hybrid crops are reported to produce 2 bags more grain per acre than crops raised with ordinary seed. The seeds produced by a hybrid crop do not carry the capacity to produce heavy crops, like the original hybrid seeds. The hybrid seeds have to be produced every time, to maintain the hybrid vigour. Extensive organisation is required for producing hybrid seeds to meet the full requirements of seeds on a country-wide scale and such an organisation is functioning in U.S.A. The research stations maintain a number of pure lines of maize and supply the selfed seeds to selected nurserymen, who grow the chosen lines of maize side by side and produce hybrid seeds on a commercial scale. It is said that over 90 per cent of the maize crop in U.S.A. is raised with hybrid seeds. Methods of producing hybrid maize were evolved even as early as the year 1923 and it took nearly 20 years for the use of hybrid seed to become

a regular farm practice even in an advanced country like the U.S.A. There is thus an inevitable time lag between research and its application in the field on a country-wide scale.

Fodder maize. Maize is a good green fodder crop cultivated like fodder sorghum. The maize fodder is sweet to taste and is relished very much by cattle. The milk yield is raised slightly when fodder maize is supplied as the main roughage. Fodder maize grows quickly and gets ready for cutting in about 2 months and the young plants are not poisonous like young sorghum plants. Maize makes the best growth in South India, when it is raised from September to February, and sorghum makes very slow growth during this period. Maize can be broadcasted at 60 to 80 lb. of seed in an acre, for the production of fodder. The yield of green fodder ranges from 15,000 to 25,000 lb. per acre, depending upon the fertility of the land and the season of cultivation.

In parts of Bombay maize is dibbled in rows 2 to 3 feet apart, for the production of fodder. A fortnight before the harvest of the fodder, maize is dibbled in rows in the interspaces between the standing rows of maize. The intersowing is continued with every crop and 5 or 6 crops of maize fodder are produced from the same piece of land, during the course of a year.

Maize is grown in considerable areas in America and Australia, for being converted into silage. Maize and sorghum fodder contain considerable quantities of carbohydrates and sugars, which promote vigorous activity of lactic organisms and generous production of lactic acid, so necessary for keeping down other organisms that may be present, in the early stages of the formation

of silage. They are, therefore, particularly suitable for ensiling and are better than most other green fodders. The nutritive value of maize silage is considerably improved by the addition of green legumes like cow pea vines and lucerne, at the time of filling the silo.

VI. 11—Wheat (*Triticum* species)

Vernacular names : Tamil - godhumai; Malayalam - kotampam; Telugu - godhumalu; Kannada - godhi; Hindi - godhi.

Importance and distribution. Wheat is the foremost grain and is the basic staple food of nearly a third of the people in the world. It is palatable and is very nutritious. It is grown all over the world, in the tropics, the warm temperate regions and even in the cool temperate regions up to 60° N. Latitude, in the last case with special varieties evolved for resisting the cold temperature. The extent of cultivation and production of wheat in the several countries of the world during the year 1952, are given in the next page.

The total extent of cultivation of wheat in the world was 446 million acres in 1952, with U. S. A., Canada and Australia as the chief exporting countries, accounting among themselves for 106 million acres. India had 23·2 million acres at the time, with 5·43 per cent of the world's acreage and 3·36 per cent of the world production. The average world yield was 993 lb. per acre, while that of India was 556 lb., which is 57·1 per cent of the world yield. India was exporting small quantities of wheat originally, but had to import wheat after 1930, caused by the demand from an expanding population.

Name of continent or country		Extent in acres (1,000s)		Production of wheat in 1,000 long tons	
North America		98,370		53,520	
	Canada		25,995		18,440
	U. S. A		70,585		34,600
Europe		71,340		44,210	
	France		11,000		8,307
	Italy		12,000		7,903
	Spain		10,625		4,554
	United Kingdom		2,030		2,308
U. S. S. R.		107,000		29,740	
Asia		115,320		43,670	
	Turkey		13,500		6,296
	India		23,235		6,591
	Pakistan		10,435		3,081
	Japan		1,781		1,514
	China (1950)		53,200		20,760
Africa		16,920		4,688	
	Egypt		1,455		1,085
	South Africa		2,996		508
South America		19,190		10,050	
	Argentina		13,500		7,635
Oceania		10,236		5,119	
	Australia		10,106		5,040
World Total		438,376		190,997	

Source: *U. S. D. A. Agrl. Statistics*, 1953—'54.

Local distribution. The extent of cultivation and production of wheat in the several states in the Indian Union during the year 1953 - '54 are given below:

Name of State	Extent in acres (1,000s)	Production of wheat in tons (1,000s)
Bihar	1,196	293
Bombay	1,978	356
Hyderabad	576	64
Madhya Pradesh	2,734	584
East Punjab	3,058	1,286
Uttar Pradesh	8,997	2,990
Other States	6,232	1,624
All-India Total	24,771	7,197

Source: *'Agrl. Situation in India,'* Aug. 54, pp. 291.

The cultivation of wheat is concentrated in subtropical India, north of 23° N. Latitude. The only State in the tropical zone having a large extent is Madhya Pradesh. Two-fifths of the area is under irrigation and the rest is grown under rain-fed conditions. Wheat is of minor importance in other States.

The normal extent of wheat cultivation in Madras and Andhra states is given below:

MADRAS		ANDHRA	
District	Extent in acres	District	Extent in acres
North Arcot	20	East Godavari	450
Salem	390	Krishna	20
Coimbatore	270	Guntur	550
Madurai	1,160	Kurnool	2,340
Nilgiris	1,200	Anantapur	1,630
		Cuddapah	650
Total (Madras)	3,040	Total (Andhra)	5,640

The cultivation of wheat is confined to small areas only in Madras and Andhra, particularly Madurai, Nilgiris, Kurnool, Anantapur and Cuddapah districts. The average yield of wheat is limited to about 350 lb. per acre and the production of wheat to about 500 tons in Madras and 1,700 tons in Andhra.

Varieties. Two species of wheat are mainly grown in India, namely *Triticum vulgare* Host. and *T. durum* Desf. A third one *T. dicoccum* Schuebbler., called 'spelt wheat,' is grown to a small extent in parts of Bombay, Mysore, Andhra and Madras. Dwarf wheats like *T. compactum* Host., were being cultivated previously in Punjab, but they have practically gone out of cultivation now.

T. vulgare is the common wheat used by the milling industry, for the manufacture of flour in India. It is grown extensively in North India, both under irrigated and rain-fed conditions. The grains are of medium size, white to red in colour and soft to hard in structure. The improved strains evolved at the Indian Agricultural Research Institute, New Delhi, are white types which occupy about 19 per cent of the total wheat area in India.

T. durum is known as the 'Macaroni' wheat. The grains are long, pointed, hard and flinty. Their gluten content is high and their colour is white, though there are amber and red-coloured types also. This wheat is grown chiefly in Madhya Pradesh, Bombay and Hyderabad.

T. dicoccum is the emmer or spelt wheat grown in the southern parts of Bombay and Anantapur in Andhra State. The grain is red in colour, hard and flinty. Coarse broken spelt wheat cooks like rice into separated grains, without getting pasty.

The wheat grown in Madras and Andhra is mostly *T. vulgare*, with small areas under *T. dicoccum* in Coimbatore, Madurai and Anantapur districts under irrigation. The glume is persistent in the latter and does not get separated from the grain during threshing. The rainfed wheat in Bellary, Guntur and Kurnool is of the *vulgare* species and threshes free of glumes.

General characters. Wheat is one of the tasty cereals, which comes up well in a mild climate as in the subtropical and warm temperate regions. The protein content of the grain is higher than that of other cereals. The wheat protein is of a special type, called 'gluten'. It is leathery in consistency when moistened and imparts the distinctive and valuable character of raising the dough made with wheat flour, when leavened bread is made.

When the gluten content is high, the grain is hard in structure and translucent, the broken surfaces are glassy in a way and there is an increase in the volume of the bread loaf made. The wheats are called 'strong wheats' and are preferred by the baking and milling industries. They tend to become soft, when grown under irrigation. The 'soft wheats' are low in gluten content and are called 'weak wheats', that is, with reference to the capacity to raise the volume of the bread loaf, which is consequently denser than hard wheat bread. The endosperm of soft wheats is opaque and chalky in appearance and broken surfaces are dull, matty and ill-defined, without distinct planes of cleavage like hard wheats.

Season. The duration of wheat ranges from 3½ to 7 months in India, being short in South India and long in

North India, where the growth is kept in check by the cold weather during the winter season. It is sown in the late season (rabi) from November onwards in North India, in October-November in the black soils of the Ceded districts and in November as an irrigated crop at Coimbatore. Two crops are raised in the Nilgiris, from April to August and October to January respectively. Sowings are done in the Kodaikanal in July and late November.

Soils. Wheat is principally a crop of the deep rich heavy soils. It is grown in the heavy black soils of Madhya Pradesh, Bombay and the Ceded districts, as a rainfed crop. It is cultivated in the deep alluvial soils of the Indo-Gangetic plain and in the virgin soils cleared in the hills for shifting cultivation.

Rotations. Wheat is grown generally as a pure crop in South India, while it is mixed with other crops and pulses in North India. It is grown as a rainfed crop in rotation with cotton, sorghum and *tenai* in the Ceded districts and with cotton, sorghum and *ragi* as an irrigated crop at Coimbatore. It is grown after the main crop of potato in the Nilgiris.

Cultivation. The lands are ploughed 3 or 4 times after the harvest of the *ragi* crop at Coimbatore and manured heavily with cattle manure at 20 cart-loads per acre. In the Kodaikanal Hills, the lands are ploughed twice and virgin soils are dug up with spades. In the Nilgiris, wheat is grown after potato, after clearing the weeds on the surface, without any preparatory cultivation or manuring.

The seeds are sown in plough furrows at Coimbatore, adopting a seed rate of 60 to 80 lb. per acre. The lands

are later laid into beds and channels for irrigation. In the Nilgiris, 100 to 120 lb. of seeds are broadcasted over an acre and covered by digging with a narrow spade, called 'guddali'. One or two weedings are given and garden land crops are irrigated once a fortnight.

The crop comes to harvest in $3\frac{1}{2}$ to 4 months in South India, drying up more or less at the time. The entire crop is cut and threshed under the feet of cattle. In the Nilgiris, the wheat sheaves are handthreshed and later cattlethreshed, like rice. The yield of wheat grain is 300 to 500 lb. per acre in the Ceded districts and 700 to 1,000 lb. in the Nilgiris, under rain fed conditions. The irrigated crop gives 1,500 to 2,000 lb. of grain and 2,000 to 2,500 lb. of straw per acre at Coimbatore. The straw is rather poor and is not used for feeding stock in South India. It is often left in the field and burnt in the Nilgiris.

Wheat is the staple food grain in North India and the average annual consumption is about 359 lb. per head of population in cities. It is low in South India, being only 10 lb. during the war years and 4 lb. in pre-war days. The demand for wheat is confined chiefly to cities and the large towns in South India.

Wheat products. Wheat is made into *ata*, *maida*, *suji* or coarse semolina and *rava* or fine semolina, for consumption. *Ata* is wholemeal wheat flour and includes bran also. It is creamy or ambery in colour and is suitable for being made into pancakes of the type of *chappathis* and *pooris*. *Maida* is the flour produced in roller mills and excludes bran. In modern mills, wheat is first washed in water and the moisture on the surface is absorbed by the grains in course of time. The moisture in the grains

is then brought to a standard level, predetermined to be the most suitable for the type of wheat and the manufacture of the particular type of product aimed at. This is referred to as 'the conditioning' of the wheat. The grains are then pressed, when they open out along the dorsal suture and expose the endosperm. This is scraped with serrate edged scrappers, leaving behind finally the outer epidermal layer of skin, with the bran attached to it. The reduction in the size of the material is brought about in stages. It is then separated into fractions of different sizes with suitable sieves. The products obtained are (1) *ata* or creamy coloured flour, including some bran, (2) *maida* or white flour, (3) semolina of different grades and (4) wheat bran used for feeding stock. The proportions of the several products obtained from the wheat grain are indicated below, as percentages of the entire wheat:

Product	Average percentage	Percentage - range of		
1. *Ata*	35	15	to	62
2. *Maida*	42	20	to	25
3. *Suji* or Semolina	6	0	to	18
4. Wheat bran	17	12	to	22

CHAPTER VII

PULSES

Importance. 'Pulses' is the name given to leguminous grains like redgram, blackgram, horsegram etc., whose cotyledons are separated from the grain and used as human food. The split pulse is called '*dhall*'. It is rich in protein and serves as a flesh forming food and is included in the diet along with rice and other cereals to make the food balanced. Subsidiary pulse products serve as stock feed.

The pulse crops belong to the natural order of 'leguminoseae'. The leguminous plants and their several produce are richer in protein than those of other groups of plants, in general. They are rich in nitrogen and enrich the lands where they are grown. This is caused by the fixation of atmospheric nitrogen in the plant tissues, during their growth. This property is not possessed by non-leguminous plants. The atmospheric nitrogen is fixed primarily by a group of bacilli, called *Bacilli radicicola,* which work in association with leguminous plants, develop into colonies on the tender root tips and form small nodules, ranging in size from a pin-head to a pea. They take the carbohydrates required for their growth and activity from the legumes, produce nitrogenous compounds absorbing the necessary nitrogen from the atmosphere and supply the leguminous host plants with nitrogenous compounds. The association is mutually beneficial and is referred to as 'symbiosis'; the bacilli get the carbohydrates for their growth from the

legumes, which in turn get supplied with nitrogen. Other groups of plants depend upon the soil for supply of nitrogen and are lower in nitrogen content. The old nodules and epidermal cells slough off from the roots of the legumes, and become part of the soil. Further, the live legume roots excrete certain nitrogenous compounds into the soil and this is a distinct addition to the stock of nitrogen already in the soil. The stubbles, roots and the remains of legume plants add their quota of nitrogen to the soil in course of time. Other crops that grow by the side of legumes get the benefit of these additional supplies of the soil. If the soil is rich in nitrogen, or if nitrogenous manures are applied liberally, the legume bacilli do not function efficiently and the fixation of atmospheric nitrogen is slowed down. The legumes require sufficient supplies of calcium and phosphorus to sustain their growth, as well as that of the legume bacilli, and they get benefited by the addition of phosphatic fertilizers. South Indian soils are rich in lime and additional supply of calcium is not necessary. The pulses are not only good sources of supply of protein, but also of calcium and phosphorus, the two substances required for building up bones.

There are many strains of legume bacilli and each strain works in association with certain legumes only and not with others. Thus, when new legumes are introduced in a locality, they may fail to make satisfactory growth, if the bacilli capable of working with them are not present in the soil. Suitable cultures of the appropriate bacilli have to be introduced into the soil, along with the legumes. The seeds can be mixed with bacilli cultures prepared in laboratories, or coated with soil, where the legumes were being grown previously. These introduce

the necessary bacilli into the soil and the legumes are enabled to make normal growth. The bacilli introduced into the soil will remain there and further inoculations are not necessary.

Pulses in rotations and mixtures. Rotations and mixtures are effective in maintaining the fertility of the land. Apart from other factors concerned, the pulses included in the rotations assist materially in maintaining the fertility. They enable atmospheric nitrogen being fixed and added to the soil. They are, therefore referred to as 'restorative' or 'recuperative' crops. Though pulses can raise the nitrogen status of the soil, they cannot influence the fertility level, with regard to other ingredients of plant food. But, since nitrogen is generally the most deficient, the maintenance of the level of nitrogen in the soil by cropping with legumes is practically effective in raising the cropping capacity of lands.

Mixed cropping is as effective as rotations in a general way. In rotations, a number of crops are included in a cycle and grown one after another. In mixed cropping, the several crops that constitute a cycle in a rotation are grown mixed together, year after year. Mixtures of crops confer, therefore, the same benefits as rotations. Pulses function alike in both rotations and mixtures. Those, used as components in mixtures, benefit the other crops grown with them. The nitrogen added to the soil by pulses is utilised by the other crops, which are enabled to make better growth. Cereals make better growth than the other crops mixed with the pulses. The spreading roots of the cereals are possibly able to forage effectively and use the nitrogen excreted by the pulses, better than the roots of the other groups of plants.

Pulses are subject to considerable damage by insects, more than others, in general. The incidence of pests is severe in certain years, and insects appear suddenly and unexpectedly, and it may be said that pulses are uncertain crops in a general way, till they are harvested. Aphids settle down in colonies on the tender parts and inflorescence of pulses, suck the plant sap and bring about considerable loss. Pod borer's damage in the field is also unpredictable. Weevils and beetles of various types bore and riddle the pulses held in storage and the damage is very severe sometimes. Pulses like redgram intended for seed are coated with moistened red earth, dried and kept in storage, as a protection against insects. The dusty

Name of pulse	MADRAS		ANDHRA	
	Area in acres	Production in tons	Area in acres	Production in tons
Bengalgram	4,900	790	101,000	19,110
Greengram	127,430	13,580	358,470	33,140
Redgram	154,850	22,700	208,140	21,140
Blackgram	150,530	15,880	143,440	16,580
Horsegram	522,150	32,810	862,110	62,010
Other pulses	200,640	14,330*	78,430	5,600*
Total pulses	1,160,500	100,090	1,751,590	157,580

Source: *Season and Crop Report of the Madras State for the year 1952-'53, (1955).*

* *Note*: The production of other pulses has been taken to be 164 lb. per acre.

atmosphere in the stored pulse checks the multiplication and growth of insects to a large extent.

India is considered to be the original home of many pulses. The composite Madras State had 26.8 lakhs acres under pulses in 1951, before partition, and produced about 2·58 lakhs tons of pulses. She had a total population of 56·9 millions of people, with an adult equivalent of 84·08 per cent or 47·9 millions. Her total requirements of pulses on the basis of 3 ounces per head per day works to 14·63 lakhs tons, with a deficit of 82·3 per cent. The available supply of pulses was estimated to furnish 0·6 ounces per head per day. Such a low intake of pulses makes the food very unbalanced.

The normal extent and production of pulses in Madras and Andhra States are furnished in page 202.

Pulses are raised under rainfed conditions, ordinarily. Irrigation is sometime provided for those raised in wet lands as off season crops and the extent of irrigation is negligible.

The percentage composition of important pulses, groundnut and major cereals are furnished for comparison in the next page.

Pulses contain 22 to 24 per cent of protein and are rich sources of protein among vegetable produce. Bengalgram and redgram have greater biological value than other pulses and it is noteworthy that they are in large use in India. Certain pulses are predominantly consumed with the major cereal grains, like redgram with rice, Bengalgram with wheat and barley, lablab with *ragi* and many kinds of pulses with sorghum and other millets. It cannot be stated definitely whether these combinations of

different pulses and cereals are a result of their compatibility at the table from the point of view of palatability, or nutrition, their compatibility in the field as associated components in mixed cropping, that is, their capacity to thrive best under identical conditions of soil and climate, or simply a traditional habit developed in different tracts, without any of these bases. These specific combinations are seen throughout India, and have been in existence from time immemorial, even in tracts wide

Name of Produce	Moisture	Protein	Fat	Fibre	Carbohydrates	Mineral matter	Biological value
			1. Pulses				
Bengalgram roasted and dehusked	11·2	22·5	5·2		58·9	2·2	76
Blackgram dehusked	10·9	24·0	1·4		60·3	3·4	64
Redgram dehusked	15·2	22·3	1·7		57·2	3·6	74
Cow pea with husk	12·0	24·6	6·7	3·8	55·7	3·2	61
Lablab with husk	9·6	24·9	0·8	1·4	60·1	3·2	41
Greengram with husk	10·4	24·0	1·3	4·1	56·6	3·6	51
Horsegram with husk	11·8	22·0	0·5	5·3	57·3	3·1	59
Soyabean with husk	8·1	43·2	19·5	3·7	20·9	4·6	54
Groundnut kernel	7·9	26·7	48·1	3·1	20·3	1·9	57
			2. Cereals				
Raw rice,hand-pounded	14·5	6·8	1·5		76·2	1·1	86
Sorghum	11·9	10·4	1·9		74·0	1·8	83
Ragi	13·1	7·1	1·3		76·3	2.2	65
Cumbu	12·5	11·6	5·0	1·2	67·1	2·7	83
Tenai	11·2	12·3	4·7	8·0	60·6	3·2	77
Varagu	12·8	8·3	1·4	9·0	65·6	2·9	
Panivaragu	11·9	12·5	1·1	2·2	68·9	3·4	
Samai	11·5	7·7	4·7	7·6	63·7	4·8	
Kudiraivalli	11·9	6·2	2·2	9·8	65·5	4·4	
Maize	14·9	11·1	3·6	2·7	66·2	1·5	60
Wheat	12·8	11·8	1·5	1·2	71·2	1·5	67*

* *Source*: Aykroyd W. R. *The nutritive value of Indian foods and the planning of satisfactory diets*, Manager of publications, New Delhi, 1951.

apart which could not have had any contact in the past, when communications had not developed.

VII. 1—Redgram (*Cajanus cajan* (Linn) Millsp. Syn. *C. indicus* Spreng.)

Common names: English - pigeon pea; Tamil - thuvarai; Malayalam - thuvara; Telugu - Kandhulu or kandhi; Kannada - togare; Hindi - tur, or arhar.

Importance. Redgram *dhall* is an important article of food in South India, where rice is the staple food grain and whose deficiencies are made up to an extent by the inclusion of redgram in the dietary, particularly in protein, vitamin B, calcium and phosphorus. The husk obtained by the separation of the *dhall* is a valuable cattle food.

Distribution. The cultivation of redgram is widespread in India. It is believed that it may have been introduced into India from South Africa, where many wild forms of redgram are found growing in a state of nature. The State-wise distribution and production of redgram in the Indian Union during the year 1953—'54 are given below:

Name of State	Extent in 1,000s acres	Production of redgram in 1,000s of tons.
1. Andhra	204	17
2. Bihar	436	94
3. Bombay	653	155
4. Hyderabad	1,147	163
5. Madras	170	24
6. Madhya Pradesh	946	572
7. Mysore	158	17
8. Uttar Pradesh	1,453	659
9. Other States	609	82
Total (Indian Union)	5,776	1,783

Source: '*Agrl. Situation in India*', Aug. 1954, pp. 292.

The chief States cultivating redgram are Uttar Pradesh, Hyderabad, Madhya Pradesh, Bombay, Bihar, Andhra, Madras and Mysore in the order of importance. In a similar way, the chief districts cultivating the crop are Anantapur, Kurnool and Guntur in Andhra and Tiruchirapalli and North Arcot in Madras as seen below:

MADRAS		ANDHRA	
District	Extent in acres (Normal)	District	Extent in acres (Normal)
Chingleput	820	Srikakulam }	15,030
South Arcot	12,970	Visakhapatnam }	
North Arcot	39,610	East Godavari	9,900
Salem	16,530	West Godavari	5,470
Coimbatore	13,600	Krishna	5,930
Tiruchirapalli	44,540	Guntur	26,210
Tanjore	6,340	Kurnool	38,180
Madurai	6,460	Anantapur	54,800
Ramanathapuram	4,750	Cuddapah	7,910
Tirunelveli	5,090	Nellore	4,690
Malabar	4,090	Chittoor	5,420
South Kanara	50		
Total (Madras)	154,850	Total (Andhra)	173,540

Varieties. Redgram is a perennial bushy type of plant in nature, which flowers and forms pods periodically and intermittently. Races suitable for cultivation as annual crops have been evolved from the wild forms.

They produce pods within a restricted period of time, which facilitates their harvest. Even so, the flowering of redgram is not so uniform as that of other crops, and flowers, young pods and dry pods can be seen together in crops that are ready for harvest. The flowering is protracted and pods mature unevenly. If the crop is kept over till all the young pods mature, the pods formed earlier dehisce and shatter the seeds. At the same time, flowers and young pods are forming on the plants. This is disadvantageous and undesirable in field crops.

A large number of varieties of redgram is grown in the several regions. Most of them get ready for harvest in 7 to 9 months. An early variety maturing in 4½ months has in recent years spread from Tenkasi in Tirunelveli district to other areas. It comes up well as a dry crop, when the rains are favourably distributed. A good crop can be raised with 2 or 3 irrigations, even when the rains are unfavourable. It is grown as a pure crop or mixed with sorghum and also on the bunds of irrigation channels in garden lands. Certain perennial bold seeded types are grown in Mysore and the Agency tracts in the Northern Circars. The seeds are big in size and they are used as vegetable like green peas.

Considerable variations are seen in the duration, spreading and growth habits, flowering period, size of pods and seeds etc., of the different varieties. The colour of the seed ranges from cream to black through different shades of yellow, red and brown. A dark chocolate red is the more common colour. The cotyledons are light to deep yellow, with a pronounced orange tinge in certain varieties.

Soils. Redgram is grown under rainfed conditions, in almost all classes of soils, as the black cotton soils, red soils, loamy soils, sandy soils and even in clayey soils. Well-drained loamy soils are particularly suitable and larger yields are obtained from them than from other classes of soils. Red gram is not grown under irrigated conditions, except in the case of perennial vegetable types. Irrigation encourages the formation of flowers and pods more or less continuously.

Rotations and mixtures. Redgram is grown both as a pure crop and as a mixture with other crops. When rains are received early in the season in May-June, it is sown as a pure crop, in rotation with cereals. It is grown more extensively later, mixed with sorghum, *cumbu, ragi, varagu* and groundnut. It is sometimes dibbled on the bunds round *ragi* beds. In the upland tracts of the Northern Circars which are under dry cultivation, rice and cotton seeds are mixed and broadcasted and redgram seeds are sown in plough furrows 6 to 8 feet apart, while covering the broadcasted seeds. The same mixture is sown every year and sometimes it is rotated with crops like sunhemp grown for fibre, chilli or tobacco.

In wet lands, redgram seeds are dibbled on the big field bunds, after the transplantation of rice. Suitable big bunds are seen in areas, where the drop in level from one field to another is considerable. Redgram, lablab, or both are sown mixed with sorghum in wet lands during the first crop season in the Tenkasi taluk of Tirunelveli district, where the south-west monsoon is feeble and does not facilitate a wet rice crop being raised during this period. The sorghum is harvested in about 3½ months and the pulse crops spread out later and cover the

ground. When the north-east monsoon sets in early, the pulse crop is ploughed in as green manure and the land is prepared for planting rice ; otherwise, the pulses are kept on and the ripe pods are gathered later.

Cultivation. The land is prepared by ploughing twice or thrice and redgram is sown with the first soaking rains of the south-west monsoon. The seeds are sown 18 inches apart in plough furrows, with 3 or 4 feet between the gram rows. Six to eight pounds of seeds are required for sowing an acre. When redgram is mixed with sorghum or other crops, the gram is sown in plough furrows, 6 to 8 feet apart. With valuable crops like groundnut, the gram is sown in rows 10 to 12 feet apart. The interspace between the redgram rows is ploughed 2 or 3 times for the removal of weeds, after the harvest of the main crop, in mixtures. Such interculture is not done in black cotton soils, particularly where rains are frequent, as it encourages vegetative growth at the expense of the pods.

The redgram crop flowers towards the end of November. Absence of rains during this period and prevalence of north-east winds promote the setting of the pods and reduce the incidence of insect pests. The crop is harvested, when about 75 per cent of the pods are mature, usually by about the end of January. If the crop is kept on longer, the ripe pods split and shatter the seeds. The plants are cut close to the ground, in the morning generally, to prevent the ripe pods from dehiscing. They are left in the field for wilting and are collected and carted to the threshing floor in the evening. They are dried and the dry plants are struck against hard floor, when the pods are shed. The seeds are separated

from the pods by flailing with bent sticks, winnowed and cleaned finally.

Redgram stalks are used as fuel. The refuse collecting on the threshing floor, consisting of leaves, immature pods and seeds, and the shell on the pods, called '*bhusa*' is dried and used as feed for cattle. It is fairly nutritious.

Yield. The yield of redgram ranges from 300 to 500 lb. of gram and 500 to 900 lb. of *bhusa* per acre in red soil areas and goes up to 1,000 to 1,500 lb. of gram and 1,500 to 2,000 lb. of *bhusa* in the rich black soils of Godavari.

Manufacture of dhall. The redgram *dhall* or split pulse is manufactured for the market on a commercial scale in certain localities only, where it has become specialised. It is rarely attempted at home, though it is done, now and then. The *dhall* is prepared as follows:

Redgram is soaked in water for about 6 hours, then mixed with about 5 per cent of its volume of red earth, and kept heaped up for about 15 hours. The cotyledons imbibe moisture and swell considerably and shrink again, when the treated gram is spread out and dried. It is next treated with a thin suspension of red earth in water, kept heaped for 12 hours, spread and dried again. The dry gram is winnowed and dehusked with hand operated small stone mills, when the gram splits and releases the cotyledons. The mill is 18 inches in diameter and the revolving upper stone slab is 4 inches thick. The split *dhall* is separated from the husk and broken cotyledons, and graded for the market.

The cotyledons swell and shrink alternately when the gram is moistened and dried, and get loosened from the seed coat. It facilitates the separation of the *dhall* from the husk, when the gram is split. The cotyledons get flattened, thin, large in size and hollowed out slightly in the centre during the treatment. The resulting *dhall* is called 'yelai paruppu', or thin leafy type of *dhall*.

Alternatively, redgram, treated with red earth and water once only, is split and *dhall* is produced. The treated gram is also kept at home and split in small lots, as and when required. The *dhall* produced is thicker than *yelai paruppu* and is preferred, as being more tasty. This is called 'gatti paruppu', or the thick type of *dhall*. The ratio of the thin type of flat *dhall* to the gram is slightly more by volume than with the thick type.

The gram is slightly roasted in parts of Andhra Desa and the *dhall* is separated straightaway with stone mills. The raw gram is sometimes smeared with a small quantity of gingelly or coconut oil and dehusked in stone mills. Dehusking is then incomplete and the unsplit grams are separated, treated with oil again and passed through the mill repeatedly, till all the grams are split. It is a laborious process, resorted to only when small quantities are dehusked at home.

There are minor variations in the methods of manufacturing *dhall* in different localities. The ease of cooking, the quality and the taste of the *dhall* seem to be influenced by the method adopted, and the earth and water used for treating the gram. The *dhall* prepared at Tirupathur (North Arcot) has a reputation for quality in South Indian markets.

VII. 2 - Bengalgram (*Cicer arietinum* Linn.)

Common names: English - chick pea; Tamil - kadalai; Malayalam - kadala; Telugu - senagalu; Kannada - kadale; Hindi - channa.

The chick pea is called 'Bengalgram' in South India, as it was imported originally from Bengal. It is called 'gram' in North India and sometimes as 'horsegram' as it is a common feed for horses. It is considered to be a native of South-West Asia and is cultivated in Asia and parts of Europe, Africa, America and Australia. It is grown throught India, in about 19 million acres; with the cultivation concentrated in North India, chiefly in Uttar Pradesh (6·44 million acres), East Punjab (2·74 million acres), Madhya Pradesh (1·36 million acres) and Bihar (1·17 million acres). The other States have less than one million acres. Its cultivation is limited to 5,000 acres in Madras and it is a minor crop only. Coimbatore is the only district of some importance, where it is cultivated in 3,400 acres. It is of some importance in Andhra, where it is cultivated in about one lakh acres, with 42,000 acres in Kurnool, 13,100 acres in Anantapur, 9,700 acres in Guntur, 6,500 acres in Cuddapah and between 3 and 4 thousand acres each in East Godavari, West Godavari and Krishna and in small areas in other districts. It is grown during the cold season and is practically the last crop sown during the year.

Plant characteristics. The Bengalgram plant has a spreading and profusely branching habit and is able to smother weeds effectively. There are many varieties, with variations in the colour of the seed coat, ranging from white to black, size of flowers, seeds etc. The seeds are $\frac{1}{4}$ to $\frac{1}{2}$ inch across, with a rounded beak and a smooth

or crinkled surface. The common variety grown in South India is rather small in size and light yellowish brown in colour. 'Kabuli gram', a variety grown in parts of North India, has smooth, white bold seeds, which are slightly sweet to taste.

Soil. Bengalgram thrives in rich black soils and alluvial soils like wheat and linseed. Its extent of cultivation in the North Indian States has the same pattern as that of wheat. It is grown in black cotton soils and in *lankas* in South India. It is also sown occasionally in wet lands, after the harvest of rice in parts of Nandyal in Kurnool district and Coimbatore.

Rotations and mixtures. Bengalgram is grown generally in rotation with cereals in dry lands. It is a restorative crop like other pulses and leaves the land fertile, benefiting the succeeding crop in the rotation. The common rotation of Coimbatore includes Bengalgram, sorghum and cotton. When preceded by Bengalgram, sorghum gets benefited to a greater extent than cotton. Bengalgram is grown after rice in the wet lands of the Nandyal valley. There are not many clear cut and well-defined rotations including Bengalgram.

Bengalgram is mixed with sorghum in the Ceded districts, with one row of gram alternating with 5 rows of sorghum. This is more common in Bellary than in the other districts. It is grown mixed with cotton in Tirunelveli and Ramanathapuram, and when the sowings are delayed by late rains, coriander is also included in the mixture. It is grown mixed with wheat in North India commonly.

Cultivation. The land is prepared by ploughing or by working blade harrows in the usual manner and the seed

is drilled, broadcasted or sown in plough furrows, 8 to 10 inches apart. Fifty to sixty pounds of seed are required for sowing an acre at Coimbatore. In the Ceded districts, about 20 lb. of seed are drilled over an acre and in the Nandyal valley, 30 to 40 lb. is the common seed rate. The seed rate is related to the extent to which the plants spread out in the different tracts. They spread out very well in Andhra Desa and to a limited extent only in Tamil Nad, where the nights are not so chill and the dew fall is less.

Rains received during the growing period interfere with the growth of Bengalgram and it is therefore sown after the close of the monsoon. By the time it is definitely known that the monsoon has broken off, the surface soil dries up and the seeds have to be sown deep, in plough furrows or drilled with special heavy drills. The drills used in Nandyal are very heavy and 2 or 3 pairs of bullocks are required for working them. The spacing given between the Bengalgram lines is 1 to $1\frac{1}{2}$ feet commonly. When moisture in the soil is very low, the seeds are soaked in water for about an hour, before sowing. Later, the land is worked repeatedly with blade harrows for compacting the soil. If the surface is sufficiently moist, Bengalgram can be broadcasted and covered by ploughing like other crops.

Bengalgram seeds germinate in 5 to 7 days from sowing. The young crop makes good growth and keeps in check the weeds that spring up, and weeding is found to be unnecessary. Occasionally, the terminal buds are clipped in parts of Bellary, with the object of inducing good branching. The crop makes growth in proportion to the chillness of the weather that prevails, within

limits. There are glands on the surface, which secrete acidic substances that are irritating to the skin and give an acid taste to the leaves. The acids on the leaf are sometimes collected in the Ceded districts by spreading thin muslin cloth over the plants at night and wringing the acids from the moist muslin in the morning. The liquid collected contains mallic and oxalic acids and is used as a remedy for colic and minor stomach ailments. The crop, from which the acid is collected or removed by sharp rains, does not set the flowers normally, and the development of pods and the yield of gram are affected to some extent.

The crop matures in 3 to $3\frac{1}{2}$ months, when leaves dry up and it is then pulled out or cut with sickles, early in the morning before sun rises, to prevent the pods from dehiscing and shattering the seeds. Labourers engaged in pulling out the plants, protect their hands from the irritating plant acids by wrapping pieces of gunny sacking. The plants are dried and threshed by treading with cattle, working stone rollers or by flailing. The yield of gram is about 500 lb. per acre in rich black soils and goes up to 750 lb. in wet lands. It is about 300 lb. in poor soils.

Uses. Bengalgram is of high nutritive value and is largely used in Indian homes. It is the basic material used for most sweet and savoury dishes. It is consumed predominantly with wheat and barley. It is lightly smeared with a suspension of turmeric paste in water and toasted over sand, kept heated in iron pans. The cotyledons swell lightly during toasting, get loosened in structure and become crunchy. The husk separates during toasting and is removed by winnowing. The

toasted gram is a favourite snack and is consumed widely. Popped rice, toasted Bengalgram and a few bananas together is a favourite combination, which provides a sustaining and well balanced lunch to people visiting fairs and shandies from distant villages. The gram is used as feed for horses in North India.

Bengalgram *bhusa* is sour to taste and is not readily consumed by animals. It is mixed with other feeds and given to cattle in Andhra Desa. It is not used for feeding stock in Tamil Nad and is consigned to the manure pit.

VII. 3. Horsegram (*Dolichos biflorus* Linn.)

Vernacular names: Tamil - kollu, or kanam; Malayalam - muthira; Telugu - ulavalu; Kannada - hurulli; Hindi - kulthi.

Distribution. Horsegram is a cosmopolitan crop which is grown as a rain-fed crop all over South India and more extensively than other pulses. It derives its importance from its adaptability to poor soil and adverse climatic conditions, which are unsuitable for most other crops. It is hence grown as a common crop in poor gravelly soils and in regions of low rainfall. The other crop that can be grown under similar conditions are castor and *samai*. The normal distribution of horsegram in Madras and Andhra States, districtwise, is furnished next page.

Horsegram is cultivated in large areas in Anantapur, Salem and Coimbatore, and moderately in Nellore, Kurnool, East Godavari, Visakhapatnam, West Godavari and Madurai districts and in small areas alone in other districts.

Madras		Andhra	
District	Extent in acres	District	Extent in acres
Chingleput	4,670	Srikakulam	117,430
South Arcot	6,080	Visakhapatnam	
North Arcot	30,770	East Godavari	65,280
Salem	193,790	West Godavari	58,760
Coimbatore	151,290	Krishna	32,200
Tiruchirapalli	19,490	Guntur	29,730
Tanjore	790	Kurnool	77,400
Madurai	51,860	Anantapur	232,660
Ramanathapuram	8,620	Cuddapah	41,290
Tirunelveli	30,300	Nellore	84,230
Malabar	2,840	Chittoor	24,200
South Kanara	21,640		
Nilgiris	10		
Total (Madras)	522,150	Total (Andhra)	763,180

General characteristics. Horsegram is a low spreading type of plant, with a pronounced procumbent habit. The flowers and pods are borne on the basal portions of the plant and are hidden by the foliage. The crop is self-fertilised. There are a large number of local varieties, with the colour of the gram ranging from light buff to black. It has a vigorous growing habit and a duration of about 4½ months. The black-seeded variety is not so

vigorous and has a duration of 3½ to 4 months. It is preferred when the crop has to be sown late in the season.

Season. Horsegram is essentially a tropical crop, which grows luxuriantly under conditions of generous rainfall. It is also capable of resisting drought to an extraordinary extent and coming up in low rainfall regions. It is sown from September to November. Seasonal sowing trials done at the Millet Breeding Station, Coimbatore, indicate that horsegram sown from January to April does not set seed and the earlier the sowing is done prior to September, the longer is the duration of the crop. The crop flowers only during the cold months of the year.

Soils. Horsegram is grown as the main crop in the poorer class of red soils. It thrives in the better classes also, which are, however, devoted to more remunerative crops. It is sown in the black soils late in the season or as a mixture with other crops. When land is newly reclaimed and brought under cultivation, horsegram is ordinarily the first crop to be sown.

Rotations and mixtures. Horsegram is sown as a subsidiary crop, late in the season, in regions where the rains favour a second crop being raised during the year, after the harvest of an early cereal crop like sorghum, *cumbu* or *tenai* and sometimes after other crops like gingelly. In the black soils of Bellary, cotton and horsegram seeds are mixed and drilled together and both the crops come up together in the same row, while in parts of Nandyal, horsegram is sown in rows alternately with cotton. It is also grown as a green manure crop after rice in wet lands, in parts of Coimbatore.

Cultivation. The land is ploughed once or twice and horsegram is broadcasted at 15 to 30 lb. per acre and covered by ploughing in Tamil Nad. In the Ceded districts, the land is prepared by working blade harrows once or twice and the seeds are drilled in lines, one foot apart. The crop covers the ground and smothers weeds. No aftercultivation is, therefore, necessary.

When the crop matures, the leaves dry up and are partially shed, and the pods turn light brown and shrivel up. The plants are then pulled out or cut with sickles, slightly wilted in the field and taken to the threshing floor. They are dried and threshed under the feet of cattle. The average yield in poor soils ranges from 150 to 300 lb. of gram and 300 to 400 lb. of *bhusa* per acre. Rich loamy soils produce up to 800 lb. of gram per acre. Horsegram is not subject to damage by insects and keeps well in storage.

Uses. Horsegram has an earthy smell and is not tasty. It is not, therefore, valued so much as the other pulses, though it is equally nutritive. It is the poor man's pulse. Roasted gram is ground with salt, chilli and coconut sometimes and consumed with rice and millets. Its greater use is as feed for stock. It is boiled and fed to horses generally. It is ground or boiled and given to cattle occasionally, during summer in the Ceded districts. It is, however, not given to milch cows and young calves.

Horsegram can be raised as a fodder crop all through the year and a high seed rate of 30 to 35 lb. per acre is commonly adopted. The yield of green fodder is about 20,000 lb. per acre under irrigation. It can be fed green or made into hay for use later.

VII. 4. Greengram (*Phaseolus aureus* Roxb. syn: *P. radiatus*).

Vernacular names: Tamil-sirupayaru, pasipayaru, or pachaipayaru; Malayalam-cheru payaru; Telugu-pesalu; Kannada-hesaru; Hindi-mung.

Greengram is a native of India and it is cultivated in 1·27 lakhs acres in Madras and 3·39 lakhs acres in Andhra. It comes up well in rich loamy soils, but not so well in the heavier types of clays, which are consequently diverted to blackgram (*P. mungo*). The normal extent of its cultivation in Madras and Andhra is furnished below:

Madras		Andhra	
District	Extent in acres	District	Extent in acres
Chingleput	760	Srikakulam } Visakhapatnam }	114,250
South Arcot	7,040		
North Arcot	3,270	East Godavari	37,590
Salem	8,040	West Godavari	2,510
Coimbatore	11,780	Krishna	80,840
Tiruchirapalli	5,450	Guntur	64,880
Tanjore	68,620	Kurnool	7,960
Madurai	1,120	Anantapur	7,540
Ramanathapuram	1,200	Cuddapah	4,560
Tirunelveli	10,350	Nellore	18,320
Malabar	1,440	Chittoor	440
South Kanara	8,360		
Total (Madras)	127,430	Total (Andhra)	338,890

Greengram is grown in large areas in Srikakulam, Visakhapatnam, East Godavari, Krishna, Guntur, Nellore and Tanjore, and in small areas in other districts.

There are many varieties of greengram, falling under two main types, namely the green and the black seeded

types. The former is common and the latter is but rarely grown. An yellow seeded variety imported from North India is sometimes seen in the Madras market. Greengram is sown in the beginning or towards the close of the north-east monsoon season. It is raised as a subsidiary dry crop mixed with sorghum, *cumbu* and other cereals in light red soils, early in the season and very rarely as a pure crop by itself. The seed rate is 5 to 6 lb. per acre for mixed crops and 15 to 20 lb. for pure crops. It is grown ordinarily as a pure crop in rice fallows in wet lands, after the harvest of rice. Gram seeds are sown over the standing rice crop, a week before harvest. It germinates and comes up with the moisture in the soil. An irrigation or two may be given, when water is available in the irrigation system. No weeding or after-cultivation is done. When it is grown mixed with other crops in dry lands, it shares the aftercultivation given to the other crops. The greengram crop flowers in 60 days and matures in about 90 days. It is harvested and threshed like other pulses and 200 to 350 lb. of gram and 500 to 800 lb. *bhusa* are obtained from an acre, on the average. The *bhusa* is valued as a good cattle feed.

VII. 5. Blackgram (*Phaseolus mungo* Linn).

Vernacular names: Tamil—ulundhu; Malayalam—uzhundhu; Telugu—minumalu; Kannada—uddu; Hindi - urd.

Blackgram is cultivated extensively in India and is used to a larger extent than greengram, its close relative. It is ground with rice and made into pan cakes like *iddali* and *dhosai*, the South Indian staple breakfast foods. It is cultivated in the same way as greengram both in dry and wet lands, but in heavier types of soils and clays. It is

like the greengram plant in general appearance, but is a shade darker, more hairy and slightly smaller in size. The yield of gram is about 250 lb. and of *bhusa* 600 lb. per acre.

The normal extent of cultivation of blackgram in Madras and Andhra States, district-wise, is as follows:

Madras		Andhra	
District	Extent in acres	District	Extent in acres
Chingleput	6,290	Srikakulam } Visakhapatnam }	21,660
South Arcot	10,650		
North Arcot	5,530	East Godavari	32,560
Salem	11,220	West Godavari	3,180
Coimbatore	8,520	Krishna	37,060
Tiruchirapalli	9,290	Guntur	42,780
Tanjore	28,640	Kurnool	3,570
Madurai	14,200	Anantapur	100
Ramanathapuram	9,290	Cuddapah	130
Tirunelveli	25,030	Nellore	1,390
Malabar	9,970	Chittoor	660
South Kanara	11,900		
Total (Madras)	150,530	Total (Andhra)	143,090

Guntur, Krishna, East Godavari, Tanjore and Tirunelveli districts have large areas under blackgram and other districts have fair areas. Anantapur, Cuddapah and Chittoor districts have negligible areas only.

VII. 6. Field bean (*Dolichos lablab* Linn.)

Vernacular names: Tamil—mochai ; Malayalam—mochakottai ; Telugu—anumalu ; Kannada—avare; Hindi—ballar.

The field bean is a native of India and it is now grown throughout the tropical regions in Asia, Africa, and

America. There are two main types, which are cultivated as field and kitchen garden crops respectively.

The field type, known as *Dolichos lablab* var. *lignotus* is a very vigorous creeping type of plant with a profuse branching habit. It is characterised by the presence of oil glands on the leaves, stems and pods, which give the plant and its parts a specific smell. The shell of the pod is stringy and not fit for use as vegetable, and the seeds are used like peas, both in the green and dry state. Certain varieties have a semi-erect habit of growth, and they are grown mixed with *ragi* in Mysore. The other varieties have a trailing habit and they are grown mixed with rainfed cereals, particularly sorghum.

Field bean is sown from June to August as a mixture with cereals in dry lands and harvested in January-February, depending upon the duration of the variety. The duration ranges from 5 to 7 months. The crop partakes the preparatory and after-cultivation operations given to the main crop with which it is mixed. It is rarely sown as a pure crop by itself and when thus sown, a seed rate of 20 lb. to the acre is adopted. As a mixture with sorghum, it is sown in plough furrows 6 to 8 feet apart and 5 to 6 lb. of beans are required for sowing an acre. The cereal crop with which it is mixed matures earlier and the ears alone are gathered, and the stalks are left in the field to serve as support for the beans to climb up. The beans make vigorous growth after the harvest of the main crops. The terminal growths of the beans are cut periodically and used for feeding cattle, particularly milch animals and work bullocks. The crop flowers after about 4 months and the pods dry up after another 5 weeks. The green pods are picked and the seeds are

used as vegetable. The ripe pods are gathered in 3 or 4 batches as they get dry and the seeds are separated by flailing with bent sticks. The plants are pulled out finally and used for feeding cattle. The yield of bean ranges from 200 to 400 lb. per acre in mixed crops. Pure crops give up to 600 or 700 lb. per acre.

Field bean is consumed only occasionally in South Indian homes. It is hard to digest, when compared to other pulses. It is boiled, slightly seasoned and used as a snack in small teastalls maintained on the road-side, for which there is some demand. It is consumed as a pulse along with *ragi* in Mysore, commonly.

The garden variety of bean, known as *Dolichos lablab* var. *typicus,* is a herbacious twiner, which is grown commonly in vegetable and home gardens, under irrigation. It has no oil glands and is free of the smell associated with the field varieties. Five or six seeds are planted in each pit, with the pits 10 feet apart each way. Scaffolding or raised wooden framework is provided at a height of about 6 feet, for the vines to spread out. Tender pods are picked and used as vegetable. The shell of the pods is free of strings and the entire pod is used. It gets crinkled on drying and the extent of crinkling is an indication of the freedom from stringiness of the green pod. Dry pods of stringed varieties are nearly smooth on the surface. Varieties with white pods do not have chlorophyll and are tasty. White pods with a wash of purple about the dorsal suture have a sweet taste and are the tastiest. Green-coloured pods have an earthy smell and a light dash of bitterness.

VII. 7. Cow pea [*Vigna catiang*; Syn. V. *unguiculata* (Linn.) Walp.]

Vernacular names: Tamil—karamani or thatta payaru ; Malayalam—mum payaru ; Telugu—alasandulu; Kannada—alsande ; Hindi—lobia beda.

Cow pea is considered to be indigenous to India. It is cultivated commonly as a mixture with cereals and as a pure crop only occasionally. It is capable of withstanding heavy rains, a trait not possessed by other pulses. There are two main types of cow pea under cultivation, as with field bean, namely field and vegetable types. Both have bushy as well as creeping varieties. Considerable variations are seen between the varieties in the different regions. It is grown extensively in U. S. A. as a common green manure and an important forage crop.

Cow pea is grown extensively in Visakhapatnam parts of the Ceded districts, Coimbatore, Madurai, Salem, Tiruchirapalli and Tirunelveli districts. It comes up well in loamy soils, though it is also grown in clayey soils in wet lands, after the harvest of rice, as a catch crop for utilising the moisture in the soil. It is sometimes grown on the bunds of rice fields and occasionally as a green manure crop. A number of kitchen varieties are grown in the Nilgiris and West Coast districts. Some of them, introduced from other countries, are choice table varieties, which compare favourably with the different popular beans. The crop is not season-bound like other pulse crops and this trait is of special value in kitchen varieties, as they can be grown throughout the year, except during the summer months.

Cow pea is sown as a field crop during the period, July to September, and is harvested from October to

December. Five to six pounds of seeds are sown over an acre in the case of mixed crops and 15 to 20 lb. in pure crops. Green manure and fodder crops are raised with 30 to 40 lb. of seed to an acre. An average yield of 300 to 400 lb. of seed and twice the quantity of *bhusa* can be expected from an acre.

VII. 8. Dewgram (*Phaseolus aconitifolius* Jacq.)

Vernacular names: Tamil—nari, kal or thuluka payaru; Telugu—mitikalu; Hindi—moth.

Dewgram is grown mixed ordinarily with sorghum for providing green feed for cattle in Coimbatore, Tiruchirapalli, Nilgiris and Tirunelveli districts. It serves as a green manure crop sometimes at Tiruchirapalli. It is grown for fodder on the light soils of Dharapuram and in clayey soils or black cotton soils in other places. The green vine is valued as a nutritious feed for milch cattle. The seed rate adopted is 2 to 3 lb. per acre for mixed crops and 10 lb. for pure crops. Pure crops are sown in July and harvested in October, before the monsoon rains commence. Dewgram is sown with the main crop in mixed cropping. The yield of green fodder ranges from 10 to 15 thousand pounds per acre and the gram yield from 150 to 300 lb. The gram is mixed with cotton seed and used for feeding cattle.

VII. 9. Soya bean (*Glycine max* (*L*) Merr. Syn. *G. soya*.)

Importance. Soya bean contains about 20 per cent of oil and 43 per cent of protein. The oil can be extracted with power crushers, but not with bullock mills. The protein content of the bean is nearly twice that of most pulses. The soya protein is the only vegetable protein,

which resembles milk casein in properties. It alkalinises the blood, while other vegetable proteins increase the acidity of the blood. It is easily digested by the human stomach, even when cow's milk is not tolerated. Soya bean is ground fine, suspended in water and filtered through muslin cloth and a milk-like fluid is produced, which is used instead of cow's milk for feeding infants in China, for making coffee etc. The soya bean suspension in water is called 'soya bean milk'. It curdles like cow's milk under lactic fermentation and soya butter can be prepared from it. In spite of all these, it has not become a popular article of food, except in China, chiefly on account of its strong raw odour. The soya flour is now deodorised on a factory scale in U. S. A., and is mixed with wheat flour for making bread and biscuits. The soya bean oil and cake are used in the manufacture of paints, plastics, and various other industries.

Soya flour, oil cake and fodder are used extensively in America. Soya bean can replace animal food to a large extent and deserves to be popularised in India, which is not able to produce sufficient milk for meeting the dietary requirements of the people, who have a predominant vegetarian habit.

Origin. Soya bean is a native of Central Asia and has been under cultivation as an important crop in Manchuria, China and Japan from time immemorial. Its cultivation in the United States of America dates from the 19th century, but its extensive cultivation and great popularity are only recent developments. It is now grown there as an important grain, forage, oil seed and green manure crop. It is being cultivated in small areas in Darjeeling, Nepal, Bhutan and other places in India.

Adaptation. Soya bean is primarily a crop of the subtropics, but comes up fairly well in tropical and temperate regions. It prefers a mild climate and moderate rainfall, as are prevalent in Central Asia. It withstands moderate water logging, but not drought. It has not taken kindly to the Ceded districts, but comes up well along the east coast regions and the Central Districts in South India.

It comes up well in rich alluvial and clayey soils. It has been grown successfully in alluvial soils and loamy soils as at Tanjore and Coimbatore respectively, under irrigation and as a rain fed crop in the Nilgiris. It is a new crop in South India and the bacilli associated with it may not be present in the soil and inoculating it with the appropriate bacilli may be necessary in many cases.

Cultivation. The land is ploughed 3 or 4 times and manured with cattle manure at 10 cart-loads to an acre. Sowings can be done from July onwards and the time of sowing has, however, to be adjusted to the duration of the variety, so that flowering takes place during non-rainy periods. The seeds are broadcasted over the field or dibbled in lines 2 feet apart, with a spacing of 6 to 8 inches between the plants in the line. The seed rate ranges from 15 to 20 lb. to an acre for grain crops and from 30 to 40 lb. for forage and green manure crops. The first weeding is done when the crop is one month old and the second weeding 3 weeks afterwards, if necessary.

Harvest. The plants shed the leaves, when the pods mature and the plants can then be pulled out and threshed under the feet of cattle. A grain yield of 500 to 1,000 lb., and 800 to 1,300 lb. of *bhusa* may be expected from an acre. Forage and green manure crops produce 12 to 18,000 lb. of green material per acre.

CHAPTER VIII

OIL SEED CROPS

Oils are present in varying quantities in grains and plant tissues. They are mixtures of glycerides of various fatty acids. They are in a liquid state at body temperature ordinarily and get solidified at lower temperatures.

Fatty oils are present in considerable quantities in certain seeds and when the oil content is over 20 per cent, they can be extracted easily by mechanical means. Seeds from which oil can be so extracted go by the name of 'oil seeds'. Certain oils are volatile at 100° C. or steam-volatile and get vaporised to a small extent at the atmospheric temperature. Some are volatile at the atmospheric temperature and the fragrance associated with flowers, lemon grass, sandal wood etc., is due to the presence of low temperature-volatile oils and varying quantities of aldehydes, ketones, esters, alcohols and phenol derivatives. They are called 'essential oils'. A large part of the oil in most seeds is not steam-volatile and such oils are called 'non-volatile' or 'fixed' oils, and the associated fatty acids are usually oleic, stearic and palmitic acids. Fixed oils cannot be distilled without decomposition. Fats are also fixed oils, but they are solid at body temperature like the several animal fats. In waxes, fatty acids are combined, on the other hand, with monohydric alcohols, like methyl alcohol.

Some oils are edible and serve as ingredients of several foods while others are inedible, being unpalatable, unwholesome, or even poisonous. Oils are used in

cosmetics, which are of particular value in the tropics, on account of their emollient and cooling properties. Both edible and inedible oils are used as lubricants and illuminants. Certain oils have special medicinal and other properties. For instance, neem oil is used as a repellant to keep off flies from wounds. Castor oil is used as a purgative. It is non-drying and does not freeze at low temperatures. It is hence valued as a lubricant for aero engines. Oils are used in considerable quantities in industries connected with the manufacture of soaps, paints, varnishes, compound lubricants, substitutes for grease, butter, tallow, oilcloth, glycerine, stearine etc. Oil seed cake is a by-product of the oil milling industry. The edible oil seed cakes are used as feed for stock. They are rich in protein and oil, and are valuable concentrated feeds. Oil seed cakes, which are rich in protein have recently been used in the manufacture of plastics and artifical substitutes for wool fibres.

Oil seeds are produced chiefly in the tropics and to a small extent in the warm temperate regions also, and are exported from these regions of production to industrial centres. They are important articles of commerce. China, India, U.S.A. and the U.S.S.R. are important oil seed producing countries, which have a large export trade in oils and oil seeds. The other exporting regions are confined to South-East Asia, West Africa, Equatorial Africa and South America.

A number of crop plants and trees produce oil seeds, but 6 only are of major commercial importance. They are the coconut, the oil palm, groundnut, linseed, soya bean and cotton seed. Others like gingelly, rape, olive, sunflower, castor, tung, mustard, the Chinese varnish tree

etc. are chiefly consumed internally and do not figure in world trade.

Groundnut, gingelly, coconut, castor, safflower and niger are important oil seeds in Madras and Andhra States. Rape, mustard and linseed are additional important oil seed crops in North India. The extent of cultivation and production of the important oil seed crops in the Indian Union during the year 1953—'54 are given below :

Name of crop	Extent in 1,000 acres	Production of oil seeds in 1,000 tons
1. Groundnut	11,356	3,772
2. Rape and mustard	5,373	826
3. Gingelly	6,132	531
4. Linseed	3,369	355
5. Castor	1,368	107
6. Coconut (1950 - '51)	1,548	475 (copra)

Source: *'Agrl. Situation in India'*,—1. Mar. 1954 ; 2. Aug. 54 ; 3. June 54 ; 4. Aug. 54 and 5. April 54. 6. *'Bull. Ind. Central Coconut Committee'*, VII. 7. April 1954, p. 242 (*Copra yield has been calculated by dividing the number of nuts by 7,000*).

The percentage composition of the important oil seeds and oil seed cakes found in the next page indicate their relative value.

VIII. 1. Groundnut (*Arachis hypogaea* Linn.)

Common names: English—earth nut, pea nut, monkey nut, and Gobber pea ; Tamil—nilakadalai,

verkadalai and manilakottai ; Malayalam—nelakadalai ; Telugu—veru senagalu and nela senagalu ; Kannada—kadalakayi ; Hindi—vilayati mung and mung palli.

Name of material	Moisture	Protein	Fat	Fibre	Carbohydrates	Minerals
Oil Seeds						
Groundnut [1]	7·9	26·7	40·1	3.1	20·3	1·9
Gingelly [1]	5·1	18·3	43·3	2·9	25·2	5·3
Coconut [1]	36·3	4·5	41·6	3·6	13·0	1·0
Linseed [1]	6·6	20·3	37·1	4·8	28·8	2·4
Mustard [1]	8·5	22·0	39.7	1·8	23·8	4·2
Soya bean [1]	8·1	43·2	19·5	3·7	20·9	4·6
Cotton seed [2]		18·02	20·60	25·74	30·98	4·66
Oil Seed Cakes						
Groundnut cake [2]		51·75	8·22	7·39	26·94	5·70
Gingelly cake [2]		46·30	9·99	4·92	27·85	11·02
Coconut cake[2] (expeller)		25·34	8·20	13·20	44·92	8·34
Linseed cake [2]		30·51	6·57	9.48	43·24	10.20
Cotton seed cake [2]		22·84	9·15	24·11	37.40	6·50
Rape cake [2]		36·37	13·41	7·70	33·19	9·03
Safflower cake [2]		42·80	8·53	15.25	26.62	6·80

Source: 1. Aykroyd W. R. *The nutritive value of Indian foods and the planning of satisfactory diets*, Manager of publications, New Delhi, 1951.

2. Sen K. C. *The nutritive value of Indian cattle foods and the feeding of animals*, Manager of publications, New Delhi, 1952.

Origin. Groundnut is an important leguminous crop, the kernels of which are rich in both protein and fat. Brazil in South America is believed to be the original home of groundnut, where allied forms of the same genus are found growing in a wild state. It spread to West Africa, the United States of America and other countries

later. American missionaries introduced it into China. The Portugese Jesuit fathers seem to have introduced it along the West Coast regions in India during the 15th century. The indigenous variety reported to be growing in Bombay and the Goa region is possibly derived from one of these early introductions. The extent of groundnut cultivation was very limited in South India, till the middle of the 19th century. It was cultivated in about 4,000 acres in 1850 in the undivided Madras State. As the varieties introduced in the earlier years had deteriorated and the area under groundnut was going down, the 'Mauritius' variety was introduced by about 1895 and it brought about a remarkable increase in the extent of its cultivation. This rose shortly after to 73,000 acres in the composite Madras State and the peak of 4·7 million acres was reached in 1937—38, with the normal extent at 4·1 million acres.

In the early years of the spread of groundnut, it was referred to as the *Cheetu Kilichan Kottai* locally in South Arcot, that is, the nut which led to the discharge of promissory notes executed by borrowers at the time of taking loans. Most of the produce was exported to foreign countries and the prevailing prices fluctuated widely from time to time; it was often 5 to 6 times as profitable as other crops. The phenomenal expansion of cultivation of groundnut shows how profit motive coupled with effective demand can stimulate the production of crops, keeping in line with the pattern and volume of trade and industry.

Adaptation. Groundnut is predominantly a tropical crop. It is distributed in the regions bounded by the tropics of Cancer and Capricorn. It is capable of accommoda-

ting itself to varying conditions of climate and soil. It thrives in regions having a mean temperature of 70° to 80° F., under an annual rainfall of 20 to 50 inches, evenly distributed during the period of growth of the crop and of the development of pods. It is not suitable for regions of higher rainfall. Rains during the time of harvest induce germination and loss of quality in the mature pods of the bunch or erect type, but not in the spreading type.

Soils. The tender groundnut pod, which is located at the tip of the peg or gynophore is thrust into the soil and it can develop only under the soil. Looseness and friability of the soil are, therefore, of great importance in facilitating the entry of the tender pod into the soil and its development there. Sandy and loamy soils, fair to rich in organic matter, are extremely suitable, though the crop is grown in many other types of soils. For instance, it is grown in the black cotton soils of the Ceded districts and Guntur, and the gravelly red soils in Coimbatore and Anantapur. Red soils which harden on drying are not suitable ; the pods do not develop properly and harvesting is rendered difficult and costly. Pods, produced in soils subject to water logging, alkaline soils and soils poor in lime content, are not filled properly.

Season. Groundnut is raised as a rain-fed crop during the monsoon season. The bulk of the sowings is made in July-August with the commencement of the south-west monsoon rains. The harvest commences in September and lasts till December, depending upon the time of sowing and the duration of the variety sown. In parts of Coimbatore (Pollachi) and Visakhapatnam, pre-monsoon rains received in April and May facilitate early sowings

and the crops are harvested in July and August. In these cases, a second short duration rain fed crop like horsegram or *panivaragu* is raised during the north-east monsoon season. But this is confined to small regions only where the rains are favourably distributed. Moisture in the soil assists the entry of pods into the soil at the time of setting and of the harvest of the crop later. Sowing is therefore attempted to be made, so as to have rains at the time of flowering and harvest.

Name of continent or country	Extent in acres (1,000s)		Production of groundnut pods in 1,000 long tons	
North America	1,750		706·3	
U. S. A.		1,513		609·8
Mexico		148		74·1
Europe	45		24·1	
Italy		11		8·0
Spain		19		11·6
Asia	16,920		5,763	
Burma		722		176·8
China		3,755		1,974
India		11,862		2,894
Indonesia		549		241·1
South America	780		317	
Argentina		350		163
Brazil		354		151·8
Africa	7,920		2,098	
Fr. West Africa		2,500		759
Belgian Congo		685		157·1
Uganda		350		185·8
Nigeria		2,544		560·3
South Africa		434		103·6
Oceania	15		5·4	
World total	27,480		8,913·8	

Source: *U. S. D. A. Agricultural Statistics*, 1953 - '54.

Irrigated groundnut crops are raised in summer in Bombay, Hyderabad, Mysore, Madras and Andhra States, from February-March to June-July.

Distribution. India, China, West Africa, the U.S.A. and Nigeria are the principal groundnut regions of the world. The distribution of the crop and the production of groundnut in the various countries of the world during the year 1952 are furnished in page 235.

The production of groundnut pods in the world was about 8·93 million long tons in 1952 and India contributed 2·89 million tons, that is, 32·41 per cent towards production and 43·16 per cent towards acreage.

Distribution of groundnut in the Indian Union during 1953—'54

Name of State	Extent of cultivation in 1,000 acres	Production of groundnut in 1,000 tons.
Bombay	2,483	726
Andhra	1,863	793
Madras	1,872	903
Hyderabad	2,137	544
Mysore	443	127
Madhya Pradesh	538	144
Uttar Pradesh	255	122
East Punjab	85	28
Orissa	63	17
Travancore - Cochin	24	13
Other States	1,596	355
Total (India)	11,359	3,772

Source: '*Agrl. Situation in India*', March, 1954, p. 850.

Bombay leads in acreage, followed by Hyderabad, Madras and Andhra States, which have large areas under groundnut. These States are in Peninsular India and contribute to about 75 per cent of the extent and 80 per cent of the production of groundnut in India. Madhya

Pradesh, Mysore and Uttar Pradesh have fair areas and other States have only small areas under the crop.

The normal extent of cultivation of groundnut in Madras and Andhra States, district-wise, is as follows:

Madras		Andhra	
District	Extent in acres	District	Extent in acres
Chingleput	42,560	Srikakulam, Visakhapatnam	193,940
South Arcot	394,220	East Godavari	5,280
North Arcot	410,760	West Godavari	23,260
Salem	247,020	Krishna	121,470
Coimbatore	267,780	Guntur	187,890
Tiruchirapalli	205,010	Kurnool	438,070
Tanjore	47,930	Anantapur	483,530
Madurai	145,360	Cuddapah	218,980
Ramanathapuram	56,220	Nellore	15,820
Tirunelveli	9,080	Chittoor	218,780
Malabar	5,380		
South Kanara	30		
Nilgiris	20		
Total (Madras)	1,831,370	Total (Andhra)	1,907,020

Kurnool, Anantapur, South Arcot and North Arcot districts have between 4 to 5 lakhs acres each under groundnut. Krishna, Guntur, Cuddapah, Chittoor, Salem, Coimbatore, Tiruchirapalli and Madurai districts have 1·2 to 2 lakhs acres each and the other districts have small

areas only. The irrigated area under groundnut is about 1·28 lakh acres in Madras, representing about 7 per cent of the total area under the crop and about 19,000 acres in Andhra representing 0·8 per cent of the extent.

In view of the increased industrial activity and internal consumption and the need to maintain and develop foreign markets, the production of groundnut requires to be increased. Madras and Andhra are surplus with regard to groundnut. They are net exporters of groundnut, groundnut oil and groundnut cake. It is considered that the production of groundnut in these two States can be increased by about 20 per cent, without encroaching on the area under food crops.

Varieties. There are two main types of groundnut, namely the 'spreading' and the 'bunch' types.

The spreading type, also called the 'runner' type, has a trailing habit and the pods are produced on the spreading and prostrate branches. It has a long duration extending from 4½ to 5 months. It is suitable for tracts which have the monsoon rains distributed over a long period. It gives heavy yields of 1,000 to 1,500 lb. of pods per acre. Since the pods are borne on the branches, they have to be collected from all over the field, and the harvest involves considerable labour and becomes costly. The kernels of the spreading type require a resting period of about 3 months, before they can germinate satisfactorily. It is a desirable character, as the mature pods do not germinate in the field and get spoiled when there are rains at the time of harvest. The common South Indian variety called 'Mauritius', 'Coromandel', or 'Mozambique' is of the spreading type and was introduced into India by about 1895. The pods have a pronounced beak, thin shell

FIG. 27. Speading type of groundnut. Note that the pods are borne on the prostrate branches.
—*Courtesy:* *Director of Agriculture, Madras.*

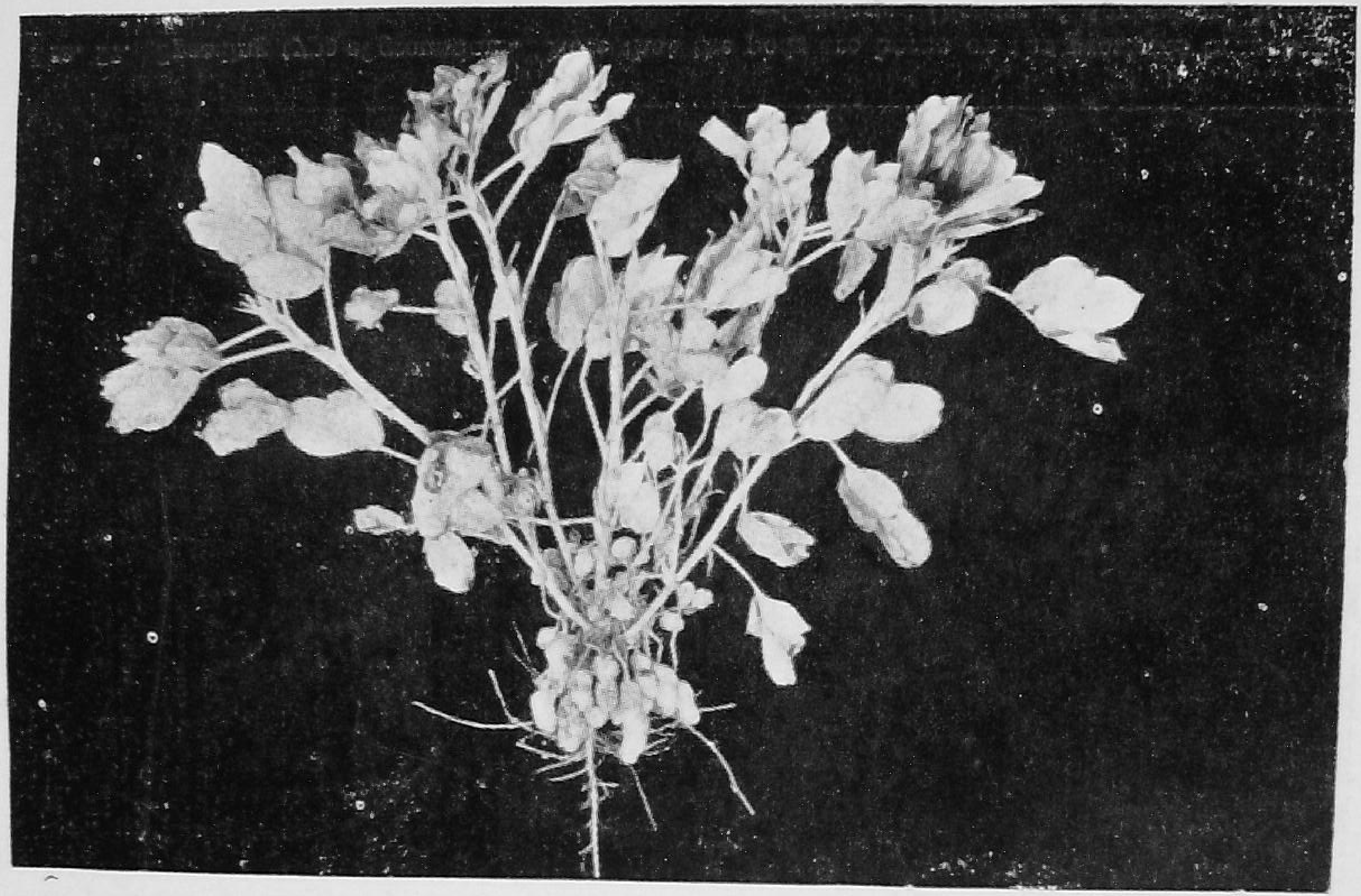

FIG. 28. Bunch type of groundnut. Note that the pods are clustered at the base of the plant.
—*Courtesy: Director of Agriculture, Madras.*

and a prominent veination on the surface. The kernels obtained by shelling are 79 per cent of the weight of the pods. The other common variety 'Saloum' is comparatively a recent introduction from West Africa.

The bunch type has an erect habit of growth and the pods are clustered at the base of the plants. When mature plants are pulled out, the pods get lifted with the plants, and remain attached to them. A few pods alone are left behind in the soil. The harvest of the crop is thus easy and convenient. The bunch type has a duration of 3½ to 4 months and is particularly suitable for tracts having the monsoon rains confined to a short period. The common variety, called the 'Spanish', 'Pea nut' or 'Natal', is largely confined to Guntur, Kurnool, Cuddapah, North Arcot and Salem districts and occupies 10 per cent of the total area under groundnut. It accounts for 6 per cent of the total exports. The seeds of the bunch type do not require a resting period, and mature pods germinate in the field when there are rains and lower the quality of the produce. This is a drawback and has been overcome by the evolution of suitable strains in Madras like T. M. V. 5, which is a cross between the local 'Gudiatham bunch' and a Tanganiyaka semi-spreading variety. The yield of the bunch type is low and ranges from 800 to 900 lb. per acre. 'Pollachi red', known also as 'Red Natal' and 'Small Japan', is an erect variety, whose cultivation is confined to about 70,000 acres in Pollachi and parts of Madurai and Tiruchirapalli.

Rotations and mixtures. Groundnut leaves the land in a more fertile condition than before and the crops that follow are benefited. Rotating groundnut with *tenai*, *cumbu*, *ragi*, or *varagu* in alternate years was found to be

satisfactory at Palur. *Ragi* following groundnut was noted to be better than *ragi* after *ragi* at Mysore. Similarly, cotton after groundnut was better than cotton following any other crop at the Cotton Breeding Station, Coimbatore. Cotton - groundnut - sorghum is a common rotation in the Ceded districts, particularly in parts of Kurnool. In South Arcot, groundnut is followed by gingelly or horsegram as a second crop in the same year. Groundnut follows rice in wet lands in many areas.

Mixing groundnut with *tenai, cumbu* and *ragi* is a common feature in dry land cultivation in South Arcot district. Redgram and castor are also sown in lines 6 to 8 feet apart, along with groundnut-cereal mixtures. Various field experiments indicate that cultivating mixed crops, including groundnut as one of the components, is more remunerative than raising pure crops of groundnut. In the Ceded districts, 2 rows of groundnut and one row of cotton alternate in mixed cropping; alternating 5 rows of groundnut with one row of cotton is coming into vogue gradually, particularly in Bellary and Kurnool districts. Sowing groundnut and cotton in alternate strips helped to arrest erosion at Hagari better than drilling groundnut and cotton alternately in the usual manner.

Preparatory cultivation. In Tamil Nad, the land is ploughed 3 to 7 times in the different tracts and brought to good tilth. The land is not prepared so thoroughly when groundnut follows groundnut. In the Ceded districts, the land is ploughed once or twice and later worked with blade harrows once or twice. The surface is evened out sometimes by working levelling board or brush harrow.

Manuring. Groundnut is not manured when the previous cereal crop is manured heavily or adequately. In most tracts, about 10 cart-loads of cattle manure and ash per acre are applied at the time of preparing the land. Where the soils are deficient in lime, applying 1 to 2 cwts. of lime has been found to be beneficial. Sugar factory ash is applied to groundnut fields round about Nellikuppam (South Arcot). Experiments conducted at Tindivanam indicate that groundnut does not require nitrogenous manuring, that potassic manures increase the yields, but not to an economic level and that the application of ash is beneficial. Application of cattle manure at 6 cart-loads per acre favoured the formation of pods, particularly in years of low rainfall. Tank silt can also be applied with advantage. *Patti mannu* or old village site earth and ash are applied to groundnut fields in the Northern Circars. Cattle and sheep are penned round about Vridachalam in South Arcot district.

Sowing. Groundnut pods intended for seed are dried thoroughly and kept stored in earthen or bamboo bins. They maintain their viability for about 2 years when kept dried in the sun periodically. The shelled kernels do not keep well in storage and pods are, therefore, shelled only when required. They absorb moisture and get mouldy, rancid and unfit for sowing after a short time, and the deterioration is rapid in humid regions.

Groundnut kernels are sown deep with special heavy drills, in lines 9 to 11 inches apart in the Ceded districts. When cotton is sown alongwith, it is sown with seed-tubes in the furrows opened with the drills and groundnut is sown through the drill hopper. In other places, groundnut kernels are sown in plough furrows. They

are dibbled with hand hoes amidst standing cereal crops at the time of the first hoeing in mixed cropping. The seed kernels are slipped into the hollows, formed in the soil at the time of hoeing. The seeds are covered automatically by the soil falling into the hollows, from the hoe blades.

Experiments conducted at the agricultural research station, Tindivanam, indicate that the spacing suitable for the crop is 6 inches either way for bunch varieties and 9 inches for spreading varieties. With such spacing, 100 lb. of kernels are required for sowing an acre in bunch varieties and 75 lb. in spreading varieties. Sowings done in dry lands in July-August, fare better than those done at other times of the year.

The seed rate adopted is to a large extent dependent on the capacity of the crop to cover the ground, which in turn is influenced by the soil, the climatic conditions, the variety and the time of sowing. Rain fed crops require in a general way a heavier seed rate than irrigated crops, red soils more than black soils and the bunch types more than the spreading types. Varieties with bold nuts require a heavier seeding than those with small nuts.

After-cultivation. Rain fed groundnuts are hoed twice, respectively at 3 and 6 weeks after the germination of the seed. Drilled crops are intercultivated with small blade harrows twice or thrice. Bunch varieties are earthed up slightly, by pressing the harrows and making them get into the soil properly. This is done with the object of providing some loose soil at the base of the plants, to facilitate the entry of the groundnut pegs into the soil and ensure their proper development. Groundnut crops cover the ground later and keep down the weeds.

Prominent weeds, if any, are pulled out with the hand. The spreading types of groundnut do not trail over the ground sometimes at Nandyal, when the branches are weighted with clods of earth, to bring about their contact with the soil and facilitate the entry of the pegs into the soil.

Groundnuts commence flowering in about 6 weeks and form pods. They should not be intercultivated later, as it would interfere with the entry of the pegs into the soil and their development.

Irrigation. Groundnut is grown mainly as a rainfed crop in South India. Small areas are under irrigation during the summer months. The irrigated areas are concentrated in South Arcot, Tiruchirapalli, Madurai, Krishna, Guntur and Cuddapah districts. Beds and channels are formed for irrigation, after covering the seeds as for other irrigated crops. Light and frequent irrigations are given, particularly after flowering to keep the soil soft and give room for.the enlargement of the pods. The crop is given 10 to 12 irrigations, in all.

The spreading type alone is grown under irrigation, as the mature pods are dormant and do not germinate in the field. They can germinate only after a period of resting. The pods of the bunch type do not need a resting period and germinate if the soil is moist.

Harvest. Both the bunch and the spreading types commence flowering by about the third week after germination and the former is in full flush after another 4 to 5 weeks and the latter after 5 to 7 weeks. The spreading type has also a second flush, 10 days after the first flush. The bunch type gets ready for harvest in 100 to 115 days and the spreading type in 140 to 145 days. When the

crops approach maturity, the leaves turn yellow and the leaf tips start drying. A small representative area in the field has to be dug to determine the stage of maturity. The outer shells of mature pods are hard and have dark veins on the inside. The papery coat over the kernels get red in colour. The harvest of crops before the pods mature fully, even by a week as practised in some places, increases the proportion of shrivelled kernels and free fatty acids in the produce. These affect both the quality and quantity of kernels obtained and promote rapid deterioration in storage.

Harvest operations consist of uprooting the plants by digging or ploughing the land, collecting the plants, stripping the pods from the groundnut haulms and cleaning them. The haulms are grazed with cattle or severed by spades, before taking up the harvest as in Tanjore. The crop is also left on the field for some time, as in parts of Villupuram, where the soils get hardened at the time of maturity of the crop. The haulms get wasted, but there is no marked deterioration of the pods. The harvest is taken up later, when the soil gets moistened by rains or by irrigation.

In Tamil Nad, the field is ploughed with the ordinary wooden ploughs or special ploughs with broad shares, called '*manvetty kalapais*'. The groundnut pods are brought to the surface of the soil during ploughing, when they are picked by women. The soil is later dug with hand hoes, for exposing the pods inside the soil. Picking the pods is done on contract, or piece work with the payment related to the quantity of pods picked by individual labourers.

In certain irrigated areas, the haulms are cut and the pods are allowed to get dry inside the soil. The fields are

then flooded with water and wet-ploughed, when the dry pods float on water and are collected easily. This method of harvest is economical, though some pods are left inside the soil. The pods are dried thoroughly before storage.

In the Ceded districts, a heavy blade harrow, called 'pedha guntaka' is weighted with sand bags and worked with 2 pairs of bullocks, along the groundnut lines. The plants are then pulled out and most pods are lifted intact with the plants. The pods are stripped, and dried, when the adhering earth drops down. The fields are later worked with special blade harrows, called '*kuracha guntakas*', which form rough ridges and furrows and assist in bringing the pods inside the soil to the surface and leaving them on the ridges.

In Guntur, the groundnut fields are dry at the time of harvest. They are worked with heavy drills without the seeding arrangement, both along and across, to facilitate heavy blade harrows being worked later, for lifting the pods. Big clods are formed when these implements are worked and picking the pods becomes difficult. But, as the land is dry and hard at the time, no other method is easier.

H. M. Guntaka No. 2 is an improved blade harrow, which is provided with a curved blade for lifting groundnut. The angle subtended by the blade and the shaft is adjustable for varying conditions of soil and types of work. The blade is set to work in groundnut fields at a depth of 5 inches, when the surface 5-inch layer of soil is slightly lifted and loosened. The groundnut plants can then be pulled out easily, with most of the pods intact. This method of harvest is suitable for sandy and loamy soils, particularly when there is some moisture in the soil.

The groundnut pods have to be dried throughly in the sun, before they are stored. The pods are heaped each evening to protect them from dew in the night. The earth sticking to the pods gets dislodged during handling, when they are being spread out and re-heaped each day during the period of drying and the final produce is quite clean.

Storage. Groundnut arriving in the South Indian market has a high fatty acid content, as (1) the crop is harvested before it is fully mature in certain cases, (2) the pods are not dried thoroughly before storage, (3) the produce is deliberately moistened sometimes prior to sale, with the object of increasing the weight, and (4) broken damaged kernels and splits form a good proportion of the shelled produce, as a result of defective decortication. These can be remedied and are only avoidable defects.

The produce obtained from the irrigated crop does not keep so long in storage as the winter produce of the dry lands. It is utilised for local consumption and is not kept over for long periods in storage.

The storage godowns have to be rat-proof, with smooth walls and rounded corners to keep off vermin, and a hard floor impervious to moisture. The godowns and the dunnage materials have to be cleaned and fumigated before storing the produce, for exterminating the storage pests resting there. The produce has to be stored as pods, and shelled only when required. Shelled kernels should not be stored on hard floors, nor kept piled to a considerable height, as the weight of the upper layers bring about caking of the kernels and exudation of oil.

Yield. The out-turn of groundnut pods ranges from 700 to 1,400 lb. per acre in rain-fed crops and 2,000 to

3,000 lb. in irrigated crops, besides an equal quantity of haulms.

Shelling. Farmers dispose of their produce as pods. Merchants pool their purchases, and shell and transport them to consuming centres. Shelling is done either with manual labour or with power decorticators.

Hand shelling is the method of extracting groundnut kernels from the pods. The pods in the heap are sprinkled with a little water, mixed thoroughly for distributing the moisture evenly, and kept heaped for a day. The softened pods are spread over the ground in thin layers and struck with sticks. The shells get broken and release the kernels. These are cleaned by winnowing, dried and kept in gunny bags. The shelled kernels get rancid and mouldy, if they are not dried properly after shelling.

Shelling is done more commonly with machines worked with power, called 'decorticators'. The pods are shelled without moistening and the kernels have a longer storage life, than hand shelled kernels. During decortication, the kernels get split and broken to some extent and these promote deterioration during storage.

The shells obtained by decortication are used as fuel for boilers and are in great demand in areas, where rice is parboiled. It is also a cheap fuel for the home kitchen. The shells decompose very slowly and cannot be composted easily or completely.

Extraction of oil. Groundnut kernels are crushed and pressed for extracting the oil. This is done in huge stone mortars in villages, called '*chekku*' or '*ghanni*' where

a big wooden pestle is kept working inside with bullocks, when the oil is pressed out.

By far the largest quantity of groundnut oil is extracted with machinery of the rotary or expeller type. The rotary mill is worked like *chekku*, with an iron mortar and pestle. The expeller type crushes the kernels, applies pressure and the oil is pressed out. Chemical solvents like petrol and ether are also used for extracting the oil. The oil is separated from the solvents by fractional distillation and is used for various industrial purposes. The solvents are recovered with suitable condensers and used repeatedly. Chemical extraction of the oil is thorough, but the cake obtained is tainted by cheap solvents and is not suitable for use as feed for stock. Groundnut kernels contain 48 to 50 per cent of oil and the oil extracted by the different methods is as follows:

Method of extraction	Percentage of oil extracted
1. By *chekku*	35 to 39
2. By rotaries	36 to 42
3. By expellers	40 to 44
4. By solvents	48 to 50

Uses. Though groundnut is grown as an oil seed crop, considerable quantities are used as roasted nuts for human consumption. The kernels are used to a smaller extent for the manufacture of confectionary of various types. Slabs made with roasted nuts and jaggery are popular snacks.

Groundnut kernels were being exported to European countries in large quantities in the earlier years, particularly to United Kingdom, France, Germany and Italy. The oil crushing industry has now been developed

considerably in the country and oil is being exported instead of the kernels.

Groundnut oil is non-drying and edible and it is in common use as a frying medium. It is decolorised, deodorised and hydrogenated, either by itself or mixed with other edible oils. The hydrogenated material is sold as vegetable ghee or *vanaspathi* and is used as a substitute for ghee and costlier oils, particularly in hotels. It is used in other countries for making margarine, a substitute for butter.

Groundnut oil, particularly the lower grade, is largely used for the manufacture of soap. It was used successfully during the period of the second world war as fuel for oil engines in place of crude oil, which was in short supply.

Groundnut cake, obtained as a by-product of the oil industry is a valuable stock feed. It is about the richest protein feed and contains a little over 50 per cent of crude protein. It is used as a nitrogenous manure for commercial crops to some extent and as one of the raw materials for the production of artificial wool fibres. It is processed and used as a cheap adhesive in the ply wood industry, instead of the costly casein. It is also used in the plastic industry.

Seed multiplication. Groundnut is not prone to natural crossing and the maintenance of purity of improved strains is easy. The multiplication of seed material in new strains that are evolved is, however, a slow process, as the seed rate is high, being 75 to 100 lb. of kernels per acre and the production of pods is limited to 8 to 10 times the seed used. Crops raised for the multiplication of strains have, therefore, to be cultivated

intensively for speeding up the rate of propagation and the rapid spread of the strains.

VIII. 2. Gingelly (*Sesamum indicum* Linn; Syn: *S. orientale* Linn.)

Vernacular names: Tamil and Malayalam—yellu; Telugu—nuvvulu; Kannada—wollellu; Hindi—til.

Gingelly, sesamum, or *til* oil is largely in culinary use in South Indian homes. It is one of the oldest oil seed crops of the world. Sunda Islands, Central Africa, Egypt and Central Asia are some of the countries that are considered to be the native homes of gingelly by various investigators. It has been under cultivation in India for long.

Distribution. The pre-war extent under gingelly in the world has been estimated to be 11·5 million acres, with a total production of 1·75 million tons of seed. India, China and Burma are important gingelly areas, which had 4, 3·5 and 3 millions acres respectively under the crop. It is cultivated in other Asian countries also and 90 to 95 per cent of the world extent is in Asia. It is cultivated elsewhere in Southern Europe, Soviet Union, Latin America, Sudan, East and West Africa and Mexico.

Gingelly is cultivated throughout India and concentrated in Peninsular India. The estimated extent and production of gingelly in the several Indian States during the year 1953-'54 are given in the next page. Uttar Pradesh, Hyderabad, Madhya Pradesh, Madras, Bombay, Andhra and Orissa are important centres of cultivation of gingelly.

Name of State	Extent in 1,000s of acres	Production of gingelly in 1,000s of tons
1. Andhra	314	38
2. Bihar	25	3
3. Bombay	346	42
4. Hyderabad	758	42
5. Madras	422	53
6. Madhya Pradesh	526	39
7. Mysore	65	5
8. Orissa	273	21
9. Punjab	65	6
10. Uttar Pradesh	1,240	86
11. West Bengal	11	2
12. Other States	2,085	194
Total All-India	6,130	531

Source: '*Agrl. Situation in India*', June 1954, pp. 153, 154.

The normal extent of cultivation of gingelly in Madras and Andhra States, district-wise, is as follows:

Madras		Andhra	
District	Extent in acres	District	Extent in acres
Chingleput	32,810	Srikakulam } Visakhapatnam }	102,980
South Arcot	42,410	East Godavari	75,900
North Arcot	16,780	West Godavari	72,210
Salem	50,390	Krishna	9,260
Coimbatore	42,470	Guntur	2,770
Tiruchirapalli	80,930	Kurnool	1,470
Tanjore	13,180	Anantapur	37,730
Madurai	26,250	Cuddapah	4,710
Ramanathapuram	16,600	Nellore	9,380
Tirunelveli	29,560	Chittoor	3,820
Malabar	5,630		
South Kanara	2,600		
Nilgiris	10		
Total (Madras)	359,620	Total (Andhra)	320,230

Madras and Andhra States have a normal extent of 3·6 lakhs and 3.2 lakhs acres respectively under gingelly. Gingelly is grown under irrigation during summer in fair areas in East Godavari, West Godavari, Srikakulam, Visakhapatnam and Chingleput districts and in small areas in other districts. The extent of gingelly under irrigation is 16,133 acres in Madras representing 4·5 per cent and 64,551 acres in Andhra, or 19·1 per cent of the extent under the crop.

Adaptation. Gingelly is a short duration crop which comes up well during long day periods. It requires a warm climate and is mainly cultivated in the tropics and to a small extent only in the subtropical regions. In India, the major areas of cultivation are in tropical Peninsular India and gingelly is grown only in small areas in North India.

It is a delicate crop which is affected adversely by unsuitable weather conditions, pests and diseases and the yield is often uncertain and low. Consequently, its cultivation does not expand and meet the effective demand. It is in short supply in general and the price of gingelly oil is higher than that of other vegetable oils. This serves as an inducement for the adulteration of gingelly oil with cheaper oils like groundnut oil.

Gingelly is rather sensitive to moisture, being affected by excessive rains as well as by drought, particularly during the early stages and during flowering.

Soil. Gingelly prefers red loamy soils of a light type, though it is also grown in black loams and heavy clay loams, which are well drained. The black soil has, however, to be ploughed repeatedly and brought to good tilth, before sowings can be taken up.

Varieties. Gingelly seeds are coloured brown, black, red or white. The different varieties are commonly recognised by their season of cultivation rather than by other characters and are named after the season as 'Kar yellu' or 'Tholakari nuvvulu' sown in April to June, 'Pyru nuvvulu' in January to March and so forth.

Season. Gingelly is sown as the main season crop in dry lands with the commencement of the south-west monsoon from May to July in South India. Small areas are sown in January-February also with the rains that may then be received. It is sown as an irrigated crop in February-March in garden lands.

Rotations and mixtures. Gingelly is an exhausting crop and the systems of cultivation and cropping followed aim at the maintenance of the fertility of the soil. It is mixed with redgram and cotton in Andhra Desa and followed by cereals in dry lands. In the Godavari region, gingelly followed by horsegram or Bengalgram is grown during the first year and 'Budama' rice, in the second year. In garden lands, *ragi* is followed by greengram and later by gingelly ; all the 3 crops are raised in the same year, one after another. In wet lands, gingelly is sown after the harvest of the rice crop in February-March.

In Tamil Nad, gingelly, *cumbu* and horsegram are grown one after another commonly. Gingelly and redgram are grown mixed together in the red soils of Coimbatore.

Gingelly is grown as a green manure crop for rice, in parts of Hospet in Bellary district. This is an instance of a non-leguminous crop being used as green manure.

Sowing. Gingelly seeds are small in size and require a fine seed-bed and optimum moisture in the soil at the time of sowing. The seeds are broadcasted at 3 to 4 lb. to an acre and covered by working light ploughs. They are mixed with coarse sand sometimes, to facilitate their even distribution while broadcasting. In garden lands, beds and irrigation channels are formed after covering the seeds. Stiff soils are wetted by irrigation to start with and gingelly is sown when the soil comes to condition. The surface soil then remains in a loose condition and the delicate tiny gingelly sprouts emerge without any difficulty. If irrigation follows sowing as with other crops, the germination of gingelly is hampered and not quite satisfactory.

After-cultivation. The crop is thinned when the stand is thick and hand hoed once or twice, depending upon the weediness. Irrigations are given to the crop in garden lands at the time of sowing, flowering and pod-setting.

Harvest. The crop turns yellow, the pods become brown and the leaves start shedding, when it matures. It is cut when about 75 per cent of the pods turn brown. If it is kept longer in the field, mature pods dry up, dehisce and shatter the seeds. The plants are kept stacked on the threshing floor for 5 to 7 days, with the shoots inside and the roots sticking out. Later, they are spread out for drying and the dry plants are struck against the floor, when the seeds are shed. The plants may have to be lightly flailed in certain cases for releasing the seeds held in immature pods. The seeds obtained by flailing are not fully developed and are kept separate. The seeds are cleaned by winnowing. The stalks are dried and used as fuel.

Yield. The yield of gingelly seed ranges from 250 to 350 lb. per acre in dry lands and 500 to 600 lb. in garden lands.

Extraction of oil. Gingelly seeds contain about 50 per cent of oil and 43 per cent can be extracted from the seed with bullock driven stone mills. Jaggery is added to the seed up to 10 per cent of its weight during crushing, to facilitate the free extraction of oil. The residual cake is a valuable cattle feed. It contains 46 per cent of protein and 10 per cent of oil. It has an appetising flavour, which is relished by cattle. It has also the repuation of stimulating the flow of milk in cows and buffalloes.

In the Circars districts, gingelly seed is held in gunny bags and soaked in water overnight. It is transferred to bamboo baskets next morning and crushed under feet gently, pouring in water frequently, for separating the husk from the kernels. It is dried in the sun for about 8 hours and winnowed free of husk. Oil is then extracted from it with country mill with the addition of 2·25 per cent of jaggery by weight and some water. The oil is kept standing for about 4 hours and the clear oil at the top is decanted. It is about a third of the weight of the seed and is called '*pappu nunae*', that is, kernel oil. It is clear and colourless. Its flavour is not so pronounced as that of the oil obtained by crushing the entire seed, but it is free of the acridity associated with the latter. The oil seed cake obtained is creamy white in colour and is seasoned in various ways and used as a side dish. It is too valuable to be used as cattle feed. The kernel oil is produced in East and West Godavari districts only.

Gingelly oil is considered to be the best of the cooking-oils in South India, from the point of view of flavour,

taste and agreeableness to the stomach. It is also smeared over the body and washed off with soap nut powder during bathing, at intervals of a week to a fortnight. The oil bath is of assistance in keeping the skin supple and healthy, and in maintaining the general tone of the system, particularly during hot weather.

VIII. 3. Castor (*Ricinus communis* Linn.)

Vernacular names: Tamil - amanakku and kottai muthu; Malayalam - avanakku; Telugu - amudhalu; Kannada - haralu; Hindi - arend.

Importance. Castor is an important oil seed crop in India, being one of the important countries providing castor oil for world trade. The oil is non-drying and does not freeze at low temperatures. It is hence a valuable ingredient used for blending and producing high grade compound lubricants, suitable for high speed aero engines. It is used in the household as a laxative and purgative and in the farm as a handy lubricant. The seeds are roasted till the shells are charred, crushed and used as a lubricating paste for farm carts. It is used in the manufacture of vulcanising materials, glycerine, artificial leather etc.

Distribution. The extent of castor cultivation in the world is about 3·5 million acres and about 5 lakhs tons of castor seeds are produced. The chief countries of production are Brazil, India, the Soviet Union, Manchuria and Argentina. Mexico has developed the cultivation of castor recently.

The area under castor in India was 1·37 million acres during 1953 - '54, with a total production of 1·07 lakhs tons of castor seed. Hyderabad, Andhra and Bombay

FIG. 29. The tree-castor.
—Courtesy: Director of Agriculture, Madras.

FIG. 30. Type of castor spikes.

—*Courtesy*: *Director of Agriculture, Madras.*

were important States with 773; 160 and 157 thousand acres respectively under the crop and produced 39; 14 and 19 thousand tons of castor seeds. Andhra State has a normal extent of 183 thousand acres and 80 per cent of the cultivation is concentrated in Anantapur, Nellore, Kurnool and Guntur districts. The normal extent in Madras is about 32,000 acres, with about 50 per cent of the area in Salem and the rest distributed in the other districts.

Castor is essentially a crop of the tropics, though it is cultivated in the subtropics also to some extent. It is a hardy crop which can stand drought remarkably well and stagnation of water to an extent. It can be grown even in high altitudes up to 7,000 feet above sea level. Castor, *samai* and horsegram are the only crops which can be grown economically on gravelly and poor soils. Castor prefers loamy soils of a sandy type, though it is grown in clayey soils as a border crop in sugarcane and chilli fields and as a shade crop over turmeric gardens.

Varieties. Castor can be divided into two main types, namely the perennial or tree castors and the annual or the field castors.

Perennial castors are distributed all over South India, but they come up best at high altitudes, from 3,000 to 6,000 feet above sea level. They have a thick woody stem and attain a height of 10 to 15 feet. Their seeds vary in size and have an oil content of 43 to 56 per cent. The leaves are used for feeding goats and Eri silk worms. The trees are established by dibbling seeds in *situ* during the rainy season. They start bearing in the same year and continue to bear for 10 to 15 years. The average yield ranges from 2 to 4 lb. of seed per tree per year.

Field castors are annual crops and have a duration of 7 to 10 months. There are a number of local varieties, with difference in the duration, the size and colour of the seeds, the spininess of the capsules, the colour of the stem and other morphological characters. Castor grown in vegetable and betel vine gardens has bright coloured small seeds and it is called '*sithamanakku*', or small castor. It is grown in limited areas and the oil is extracted at home and used for medicinal purposes.

Rotations and mixtures. Castor figures in many rotations, like other crops. The following are some of the common rotations in vogue in the Ceded districts:

1. Sorghum - castor - *tenai*,
2. Sorghum - *korra-pathi* - castor and
3. *cumbu* - castor - *korra-pathi*.

Castor and lablab is a common mixture in the red soils of Coimbatore. Castor is sown 6 to 8 feet apart in groundnut fields in North Arcot district. It is grown on the bunds of turmeric fields, for providing light shade to the turmeric crop. It is also grown with *ragi* similarly, sometimes. It is planted round sugarcane fields and betel vine gardens in some regions.

Season. Castor is sown in June-July along with the first soaking rains in the Ceded districts and in October in the Northern Circars. It is sown mixed with other crops in July in Tamil Nad and as a pure crop in September.

Cultivation. The lands are ploughed 2 or 3 times and castor seeds are sown in plough furrows, 4 to 8 feet apart, depending upon whether it is raised as a pure crop

or mixed with others. The seed rate varies from 4 to 8 lb. per acre. Experiments indicate that for pure crops, a spacing of 3 feet by 3 feet may be the most suitable. The spacing given between rows in mixed crops, depends on the importance attached to castor and its associate crop by individual peasants. The germination is very satisfactory, when the seeds are soaked in water for about 24 hours before sowing. The crop shares the inter-cultivation given to other crops associated with it. Ploughs and blade harrows are sometimes worked between rows in pure crops. Since the crop is hardy, interculture is not particularly important or necessary.

Harvest. Castor capsules start maturing from the fourth month onwards and spikes approaching maturity are gathered periodically, to prevent them from drying on the plant and shattering the seeds. The spikes are kept heaped together and fermented for about 10 days and dried; the seeds are separated from the capsules by flailing with thin sticks. The fermentation affects the quality of the seeds adversely; the oil in the seed decreases by 2 to 3 per cent and deteriorates by liberation of free fatty acids in the kernels. This can be avoided by drying the spikes in the sun, without subjecting them to fermentation and dehusking them when convenient. The seed material can be shelled at the time of sowing.

Extraction of oil. Castor oil is extracted with hand or power presses, after crushing the seeds. Heat is sometimes applied to the crushed seeds for reducing the viscosity of the oil at the time of extraction and increasing the efficiency of extraction of oil. It includes some albuminoid materials present in the kernel. It is therefore boiled with water, when the albuminoids coagulate and

float as a scum on the surface of the boiling liquid. The scum is removed, and the oil is decanted and boiled free of water. The oil so obtained by the application of heat to the crushed seeds is called 'hot drawn oil'. Oil obtained without the application of heat is called 'cold drawn oil'.

Oil is extracted from castor seeds directly, or from kernels obtained by decorticating the seeds. The cake obtained from the former is black in colour and that obtained from the latter is dirty white in colour. The cake contains a poisonous principle, called 'ricin', and is not edible. It is used as manure. The white cake has 6·3 per cent of nitrogen and 2·6 per cent of phosphoric acid and the black cake has 4·5 per cent of nitrogen and 1·8 per cent of phosphoric acid.

Home extraction of oil. Castor oil is extracted for medicinal use at home itself. The seeds are crushed to a fine paste and boiled with water. The oil separates and floats on the surface, when it is skimmed with ladles and boiled free of water. The oil obtained is 30 to 32 per cent on the weight of the seed.

Yield. The average yield of castor seed in South India is 300 to 500 lb. per acre from pure crops and 100 to 250 lb. from mixed crops. Irrigated crops give 1,200 to 1,500 lb. of seed per acre.

VIII. 4—Linseed (*Linum usitatissimum* Linn.)

Vernacular names: Tamil—alividhai; Telugu—avisi; Kannada—agasi and alasi; Hindi—alsi.

Distribution. Linseed is one of the oldest crops under cultivation in tropical and temperate regions. It is rather peculiar that it is only an oil seed crop in hot countries like

India, Argentina and tropical America, while it is a fibre crop in temperate countries like Europe. The fibre plant is called 'flax' and the fibre is used for making excellent textile fabrics. Fibre extracted from crops grown in the tropics is poor and lacks in the characteristic qualities associated with flax. Linseed is cultivated in about 3.3 million acres in the Indian Union. It is grown in small areas only in South India, with 2,960 acres in Madras during the year 1952—'53, mostly in Tiruchirapalli district, and 1,347 acres in Andhra State, mostly in Kurnool district.

Adaptation. Linseed is an exhausting crop, which prefers a medium heavy, well drained soil. It is cultivated largely in black soils and alluvial soils in India. It requires abundant moisture, a cool climate and light, but well-distributed rains. It is, therefore, raised as a late season crop in the black cotton soils of Kurnool district, practically after the heavy rains cease. It does not stand heavy rains even so much as a dry climate. On the other hand, flax grown for fibre in temperate regions does not come up in a dry climate. It is a delicate crop which requires careful and timely cultivation.

Varieties. There are two main varieties of linseed in India, which go by the name of 'Bold brown' and 'Small brown', having oil contents of 45 and 38 per cent respectively. There are also some yellow and white seeded varieties, but they are not important commercially.

Cultivation. The soil is ploughed a number of times and linseed is sown either as a pure crop or mixed with sorghum, during the month of October. The spacing given to pure drilled crops is 18 inches between rows and 4 inches between plants in the row. The seed rate used

is 2 to 3 lb. per acre for mixed crops and 8 to 10 lb. for pure crops. The crop is intercultivated twice with hand hoes or with blade harrows, depending on whether the crop is broadcasted or drilled. It is 1½ to 2 feet high at the time of flowering. It is cut when the seed capsules mature, before they become dead-ripe, when they will be about 100 days old. The plants are dried in the sun and threshed under the feet of cattle. An yield of 300 to 500 lb. of linseed per acre is obtained from pure crops and 150 to 200 lb. from mixed crops.

Linseed oil is extracted with country mills or power expellers. The oil from the former is cold-drawn and is used as a cooking oil. Hot drawn oil is used as a transparent varnish for wood work and as a medium for suspending pigments in paints and varnishes. The oil is also used in industries connected with the manufacture of oil cloth, patent leather, soap, leather substitutes, hydrogenated oils etc. The seed is crushed, cooked in water and used for feeding calves.

VIII. 5—Safflower (*Carthamus tinctorius* Linn.)

Vernacular names: Tamil—kusumba; Telugu—kusumbalu; Kannada—kusumbe; Hindi—kusum.

Safflower is an oil seed crop of minor importance. Besides, a dye for colouring cotton, woolen and silk fabrics can be extracted from the flower petals. It was in common use before the discovery of aniline dyes and not in much demand now.

Safflower is cultivated all over India, in about 6 lakhs acres, confined largely to the black cotton soils of the Ceded districts and parts of Bombay, as a rain fed crop. It is grown in very small areas in Madurai

Ramanathapuram and Tirunelveli districts. It is raised in loamy soils under irrigation in other places. It does not tolerate heavy rains and does not come up properly, in regions where the annual rainfall exceeds 35 to 40 inches.

Varieties. There are two main varieties in the Ceded districts, called 'Bodi kusumba' and 'Mullu kusumba'. The former is free of thorns and bears reddish and orange coloured flowers. It is grown as a pure crop and is highly valued for its superior dye quality. The flower petals are also used for adulterating the more valuable *kungumapoo* (saffron), which is a fragrant material used for colouring sweetmeats. The 'Mullu kusumba' is the more commonly grown variety. It has thorny leaves and yellow flowers, and it is grown for the production of seed only.

Cultivation. Safflower is grown commonly mixed with sorghum in the Ceded districts, from October to January-February and as a border crop round sorghum, wheat, gram and linseed fields, to prevent cattle trespass. The land is prepared as for other dry crops and is not manured, ordinarily. Cattle manure is applied to irrigated crops. The seed rate adopted is 3 to 4 lb. per acre for mixed crops and 10 to 12 lb. for pure crops.

The crop flowers in about 3 months and the flowers are gathered on alternate days, before they open and in any case before the petals of the opened flowers fade. The flowers are dried in shade, rubbed with a little gingelly oil and dried in the sun finally. The dry flowers are powdered, sifted through close meshed sieves and used for the extraction of the dye. The yield of flowers is about 100 lb. per acre.

The seed crop is harvested, when the leaves turn yellow and start drying in about 4 months. The plants are cut, dried and threshed by flailing with bent sticks or under the feet of cattle, during the cool hours of the day or at night. The yield of seed ranges from 300 to 500 lb. in pure crops and 100 to 150 lb. in mixed crops. The oil is extracted with bullock mills and the yield of oil is about 25 per cent of the weight of the seed. It is a pale yellow sweet oil, which is used for culinary purposes in the Ceded districts. The cake is used for feeding cattle.

Hot drawn oil. Safflower oil is also extracted by applying heat in an ingenious way in the Ceded districts. A mud pot is buried inside the soil, with the mouth upward and another pot is placed over it at ground level. The pot at the top is perforated with holes at the bottom and it is filled with safflower seed, crushed into a fine paste. The junction between the two pots is sealed with wet mud paste. Dried cow - dung cake is arranged round the pot at the top and burnt. The crushed seed inside gets heated, and oil separates from it and trickles down to the pot placed below. The oil obtained is lightly coloured.

VIII. 6 — Coconut (*Cocos nucifera* Linn.)

Vernacular names: Tamil and Malayalam - thennai; Telugu - thenkaya; Kannada - tengu; Hindi - narial.

Importance. Coconut is a unique palm tree that is useful in many ways. Every part of the tree is of some use and so it is rightly called '*kalpaka vriksha*' or the tree that gives all that is desired. The inflorescence gives on tapping a sweet juice which serves as a refreshing beverage. It is boiled and made into jaggery, sugar and sugar candy.

The sweet palm juice ferments and gives an alcoholic drink, called '*toddy*'. The stalk of the inflorescence serves as a brush for white-washing. The fruit stalk is a handy tooth brush, in the fresh state. The tender coconut furnishes a soft meaty kernel and a sweet drink, which appease hunger and thirst. The mature nut is an indispensable ingredient in everyday cooking in Indian homes. The dried kernel or 'copra' gives on crushing a sweet cooking oil and the residual cake is a valuable cattle feed. The coconut oil boils at a temperature higher than other oils and is particularly suitable for frying crisp articles of food. It is a useful cooking medium which is used in many other ways, for dressing hair, lighting, and for the manufacture of hydrogenated fat, soap, glycerine, toilet preparations etc. The husk covering the nut serves as the raw produce for the manufacture of coir, yarn, ropes, matting and brushes of various types. The shell is used for making activated charcoal, spoons, ornamental cups and saucers, decorative figures, buttons, snuff box and a number of other handy miscellaneous articles of everyday utility. It is also used as fuel for heating. The leaf is made into fans, baskets, brooms etc. It is also used for thatching roof. The stem serves as light timber and fuel. The roots are used in the preparation of certain medicines and dye stuffs.

Adaptation. Coconut is a perennial tree which flourishes in the humid tropics. It makes luxuriant growth along coastal regions and it is considered that it is due partly to the beneficial influence of the sea breeze. This is possibly exaggerated, as coconut grows luxuriantly even in inland deltaic areas in Peninsular India and the Mysore plateaux, not subject to the influence of the sea breeze.

Coconut requires a copious rainfall distributed properly over the several months of the year, but it does not stand stagnation of water. Both moisture, and aeration of the soil are necessary for promoting the growth of the crop.

Coconut flourishes in coastal sandy soils, even where they fringe the back waters, bathing the roots of the trees in sea water. It also comes up well in deep alluvial soils which are fertile and have facilities for copious irrigation and adequate drainage. It does not withstand stagnation of water and alkalinity. Yet, it withstands salinity in coastal areas, which are laden with varying quantities of common salt. Applying common salt to coconuts is a common practice in the West Coast of Madras, but this is not found to be necessary in inland areas, which cannot be said to be rich in sodium salts. Possibly, the application of common salt is able to liberate potash from the coastal soils, which are low in available potash, required by coconut in large quantities.

Distribution. The total extent of coconut is estimated to have been 8·4 million acres in the world during the year 1950-'51 and its distribution in the several countries, as also in the several Indian States is furnished below:

Name of country	Area in million acres	Production in million nuts	Yield of nuts per acre
Phillipines	2·4	3,406	1,419
India	1·5	3,324	2,216
Netherland East Indies	1·5	3,200	2,183
Ceylon	1·1	2,344	2,133
British Malaya	0·6	850	1,417
British South Sea Islands	0·6	750	1,250
Others	0·7	900	1,286
World Total	8·4	14,774	11,904

Name of state	Area in million acres	Production in million nuts	Yield of nuts per acre
Travancore - Cochin	0·661	1,322	2,000
Madras and Andhra	0·637	1,576	2,412
Mysore	0·186	297	1,600
Bombay	0·031	47	1,888
Orissa	0·011	34	3,119
West Bengal	0·017	22	1,346
Assam	0·004	22	7,365
Other States	0·001	2	2,000
Total: All - India	1·548	3,322	21,690

Source: '*Bull. Ind. Central Coconut Com.*, VII. 9, Apr. 1954.

The normal extent of coconut cultivation in Madras and Andhra States is as follows:

MADRAS		ANDHRA	
District	Extent in acres	District	Extent in acres
Chingleput	5,810	Srikakulam, Visakhapatnam	12,410
South Arcot	3,410		
North Arcot	12,090	East Godavari	56,290
Salem	9,510	West Godavari	10,430
Coimbatore	11,870	Krishna	920
Tiruchirapalli	7,580	Guntur	140
Tanjore	37,100	Kurnool	50
Madurai	8,350	Anantapur	430
Ramanathapuram	4,300	Cuddapah	130
Tirunelveli	4,790	Nellore	270
Malabar	387,000	Chittoor	2,520
South Kanara	54,080		
Nilgiris	10		
Total (Madras)	545,900	Total (Andhra)	83,590

Malabar district has the largest area under coconut. South Kanara, Tanjore and East Godavari are also important areas of coconut cultivation. North Arcot, Coimbatore, Salem, Madurai, Tiruchirapalli, Srikakulam and West Godavari districts have 7,500 to 12,000 acres of coconut each under the crop.

Varieties. There are a number of varieties of coconut under cultivation, with variation in growth habits, size and colour of nuts, oil content, copra content, colour of leaf and so forth. Two main types are recognised namely the 'Tall' and the 'Dwarf' types. The tall type is of great height and lives for 70 to 90 years under favourable conditions. The production of nuts, copra, oil and fibre is satisfactory and these products are of good quality. The nuts are of medium size in general, round or elongated, and green, yellow, orange-yellow, or greenish brown in colour. The trees commence bearing in 8 to 10 years. The nuts give 5 to 8 ounces of copra each and the copra has an oil content of 66 to 72 per cent.

The dwarf type is short in stature and lives for 30 to 40 years. It bears nuts from the third or fourth year after planting. The nuts are small in size, green, orange or yellow in colour and attractive. The produce is not, however, so satisfactory either in quantity or quality, as in the case of the tall type. The copra is leathery and poor in quality and each nut gives about 3 ounces of copra. The dwarf type is not commercially important. It can be grown in house compounds for decoration and for the production of tender nuts, which provide a sweet refreshing drink.

Seed material. All the coconut trees, even in a garden, do not bear nuts uniformly; there are shy, medium and heavy bearers. This is the result of planting unselected material. Coconut trees have to be selected as mother trees on the following basis:

1. The seed-nuts have to be secured from areas, where the cocouut trees have a reputation for heavy bearing. Trees bearing uniformly well year after year and 30 to 40 years old should be selected as mothers

for providing nuts for planting. Heavy bearing is a result not only of soil fertility and other environmental conditions, but also of the inherent make-up of the tree, which alone is transmitted to the progeny. If all the trees in the garden selected for the collection of seed-nuts bear uniformly well there will be no chance for pollen from shy bearers to fertilise and lower the inherent capacity for production of the plants raised from these seed-nuts. This is significant as coconut is cross-fertilised and the trees contributing pollen and the mother trees together transmit bearing capacity to the progeny.

2. The number of all the nuts carried by a tree at any time is roughly equal to its annual yield of nuts.

3. Trees should have regular bearing habits, that is, the bearing should be the same every year, without any periodicity or irregularity. In most gardens, some trees bear heavily in alternate years and some only once in a way, while a few trees alone bear well regularly, every year.

4. Trees selected for collection of seed-nuts should be vigorous and robust, bearing a large number of leaves. The stalks of the leaves and the inflorescence should be short, thick and strong; otherwise the leaves and the fruit bunches tend to droop.

5. Trees with medium sized round nuts are more satisfactory than others, in general, with regard to the production of nuts and copra. The thickness of the meat in the nut is related to copra content and it has also to be considered at the time of selecting the parent trees.

6. Isolated trees in house compounds and cattle sheds have a favourable environment and bear heavily.

They may not be intrinsically so good as to pass on the heavy bearing habit to their progeny. Such trees should not be used as parents.

7. Trees which do not develop the nuts properly and which tend to shed immature nuts should not be used as parents.

Quality of seed-nuts. The quality of the seed-nuts also influences the seedlings, and the seed-nuts have to be selected on the following basis:

1. The nuts harvested in February to May are the best sized among the several harvests and they produce healthy and vigorous seedlings. They should be preferred for planting.

2. The nuts which are fully mature, but not dead-ripe should be used for planting. Dead-ripe nuts lose the 'water' inside the kernels easily and they do not then germinate.

3. The nuts at the base and the top of the bunches are not as good for propagation, as those in between.

The seed-nut bunches are cut and lowered to the ground by means of ropes, to avoid injury to the nuts by impact with the hard soil below, when they fall down. The harvested nuts have to be stored in shade, when the husk dries up and the nuts get ready for planting. The nuts in storage may preferably be kept buried in dry sand, to minimise the chances of the meat inside drying up and turning into copra, during the hot summer months, as it has been pointed out that the nuts harvested in February to May have to be used for planting.

Nurseries. Coconuts are planted in nurseries and the seedlings are later transplanted in the field. The seed-nuts

and the young seedlings are subject to damage by termites and the surface of the nursery is, therefore, made up with a layer of sand $1\frac{1}{2}$ feet deep. The nursery beds may be 5 feet wide, with 2 feet in between adjacent beds to serve as foot path, while watering the beds. The seed-nuts are buried in the sand with the husk just appearing on the surface, either flat in the natural position, or vertically with the stalk end upward. The nuts may be spaced $1\frac{1}{2}$ feet either way, when the seedlings have to be lifted for planting after a year and 2 to $2\frac{1}{2}$ feet apart when 2 or 3 year old seedlings alone are required. Alternatively, one year old seedlings may be lifted and planted in a second nursery 3 to 5 feet apart. The seedlings can be kept in the second nursery up to 3 years and later planted in the field.

The nursery is kept moist by watering frequently so as to provide sufficient moisture for the nuts to germinate. Germination commences in 3 months and is completed in 5 months. Light shade may be provided for the nursery during the summer months. Manuring or any other operation is not necessary. Kerosine or crude oil emulsion may be mixed with irrigation water once in a way, to ward off termites, when necessary. B. H. C. preparations may also be sprinkled over thenursery at one ounce per 50 square feet and raked into the soil, as an additional precaution.

Selection of seedlings. Marked differences are observed between seedlings which are over 9 months old and it is possible to predict from certain characteristics of the seedlings, how their bearing capacity will develop later. The observance of the following principles are of assistance, while selecting seedlings for planting.

1. The seedlings selected should be healthy, vigorous and robust, with a large number of leaves, good girth at the base, short and thick leaf stalks, and vigorous growth of roots. Such seedlings develop into heavy bearing trees later.

2. Early germination of seed-nuts is associated with early bearing and seedlings that emerge early have to be preferred to others.

3. The splitting of the leaf into leaflets at an early stage is a sign of vigour of the seedlings.

When seedlings are selected on the above basis, 20 to 40 per cent of the seedlings produced may have to be rejected. It is, therefore, necessary to provide for these rejections and defective germination, and plant 50 per cent more seed-nuts than what is required in the begining itself. This increases the cost of the seedlings, but this is more than made up by the heavy bearing of the trees later. The seedlings have to be removed from the nursery, only when actually required for planting, by cutting the roots and not by pulling the seedlings.

There is great demand for selected seedlings, from farmers. Selected coconut seedlings are raised and distributed from the Central Coconut Research Station, Kasargode, in South Kanara district and some agricultural stations. A large number of seedlings are being supplied from these centres to farmers regularly, for meeting their requirements.

Age of seedlings. Young seedlings that have just sprouted establish readily without failure when transplanted, but the nuts attached to the seedlings are liable to damage by termites in the field. The quality of individual

FIG. 31 Coconut seedlings, one year old.

The seedling marked (1) on the left is poor and has to be rejected. Seedling marked (2) on the right is vigorous and has a large number of leaves, with stout leaf stalks; the leaflets have also split early.

—*Courtesy: Director of Agriculture, Madras.*

seedlings can be determined after they are 9 months old and they cannot be selected when they are planted in the young stage. A certain number of trees will then turn out to be shy bearers and the total yield from gardens will be affected adversely. Seedlings, 1 to 1½ years old, may safely be used for planting. Sometimes, 4 to 6 year old seedlings are planted with the object of keeping the planted area limited and reducing the cost of maintenance of gardens in the early stages. The interval between planting and the commencement of bearing is reduced by planting aged seedlings. They have to be kept in position after transplantation by tying them to stakes planted by their side, till they develop a strong root system.

Spacing. Coconuts are planted in the field rather irregularly and close to one another in general, except in large plantations. When they are planted regularly in straight rows, intercultivation can be done with bullock hoes and ploughs conveniently, and the gardens kept free of weeds at a low cost. The distance allowed between trees has a large influence on the total yield of nuts and is of considerable importance. When trees are wide apart, they are vigorous and produce a large number of nuts individually. But then, as the number of trees is limited, the total production of nuts from gardens may be low. When the trees are planted too close, their number is increased, there is considerable overlap of the leaves of adjacent palms, the individual trees produce only a small number of nuts and this again keeps down the total production of nuts from the gardens. In between these two extremes, there is an optimum spacing, which gives the maximum production of nuts. The space in the gardens is then fully utilised, without much overlap of the leaves of adjacent trees. Taking these into considera-

tion, it may be said that coconuts can be planted 25 to 30 feet apart either way, depending upon the fertility of the soil, with 50 to 70 trees to the acre. Trees on bunds and channels can be 18 feet apart.

Preparation of the field. As lands selected for planting coconut are generally under cultivation, they require very little of preparation. Pits 3 ft. x 3 ft. x 3 ft. are dug at suitable distances from one another, 2 months before planting and the dug-up soil is allowed to weather. The bottom of the pit is loosened by crow-barring and the pits are filled with loose earth, made up of top soil and fine sand, to a depth of one foot. Small bunds are formed round the pits in heavy rainfall regions to prevent rain water flowing in and stagnating. Selected seedlings are then planted in the pits, soil is pressed about them up to the collar line and pot watering is done. If any soil is laid above the collar line, it will get into the shoot and bring about rotting.

The depth at which seedlings are planted is important. Roots develop from the swollen base of the palm, called the 'bole'. The seedlings have to be planted at a depth of 2 to 3 feet below the surface, so that the bole developing in due course may be inside the soil. In hill sides and in rain fed regions, where the water table is likely to be low down in summer, the seedlings have to be planted at a depth of 4 to 5 feet. In low lying areas, the seedlings have to be planted on the surface and the bole covered with a thick layer of soil, as it develops.

Coconut seedlings may be planted 2 months before the break of the monsoon, to enable them to establish and start growth with the monsoon. It will also save watering

charges. Water collecting in the pits during rains has to be baled out.

Care of the young garden. Young coconut gardens require to be protected with fence against trespass by cattle and other livestock. If the leaves of the young seedlings are nibbled by stock, the plants lose vigour and growth is slowed down. Walls are built with mud or laterite stones round coconut gardens in Malabar. Wire fencing may be satisfactory, but is costly. Bamboos and thorny branches may also be planted round individual pits for protection.

The seedlings are pot watered on alternate days during periods of dry weather in the first year and once in 3 or 4 days later, till the plants are 6 years old. They develop a good root system by then and do not require irrigation later, except during hot weather.

The pits are cleared of weed growths periodically and pests are tackled as they appear. White ants have to be kept in check and rhinoceros beetles boring into crowns have to be removed with hooked wires. The pits are filled up in stages, as the stem develops. Green manure crops may be raised once in 2 or 3 years during the rainy season and ploughed in, for maintaining the fertility of the land.

Manuring. Coconut trees produce one leaf every 30 to 40 days and an inflorescence develops from each leaf axil. It takes about 1½ years for the primary bud in the leaf axil to develop and form flowers, and another year for the flowers to develop into mature nuts. There are 9 to 12 bunches on trees at any time, in different stages of maturity. The production of leaves, flowers and fruits is a continuous process and coconut trees make

a constant demand for plant food from the soil. It has been computed that an average crop, which produces 2,000 nuts from an acre annually, removes 18 lb. of nitrogen, 5 lb. of phosphoric acid and 38 lb. of potash from the soil. If manure is not applied in a year, it will have its influence on the primary buds that are then formed. The effect of manuring on the production of nuts can be seen only 2½ to 3 years after its application, the period taken for the development of nuts from the time of formation of the flower buds. In view of this, coconut has to be manured regularly every year, for maintaining uniformity of bearing.

Manurial experiments on coconut in South India have been confined to the agricultural stations in the West Coast, where the heavy rains have leached the soil and coconuts respond to nitrogenous and potassic manuring, with practically no response to phosphates. It has also to be stressed that cultivation of coconut gardens is at least as necessary as manuring; cultivation often gives a better response than even manuring.

Application of manures. Manuring coconut in the West Coast may commence with the sowing of a quick growing green manure crop in the month of May. Four pounds of ammonium sulphate, 2 lb. of bone meal and 2 lb. of muriate or sulphate of potash may be applied to each tree in September, at the time of ploughing in the green manure, after the close of the south-west monsoon. The fertilizers may be broadcasted and ploughed into the soil, the deeper the better. Broadcasting is better than applying in trenches by the side of individual trees, especially in old plantations. The trees have feeding roots spread over the entire garden and applying the

manures in trenches can feed only a few roots. If green manure crops are not sown, green leaf may be applied at 50 lb. per tree, annually. Groundnut cake can be applied instead of ammonium sulphate at 12 to 15 lb. per tree. Wood ash can be applied at 30 lb. per tree, instead of the sulphate or muriate of potash in November-December and ploughed in. Cattle manure can be applied to coconuts at 100 lb. per tree, instead of ammonium sulphate, bone meal and ash. But, cattle manure is not always available in sufficient quantities.

Rainfall is limited in other coconut regions and growing a green manure crop is not feasible. Green leaf, ammonium sulphate and bone meal can be applied in September. Wood ash can be applied towards the close of November, at 10 lb. per tree. Regions outside the West Coast in South India are not deficient in potash and application of ash in large quantities as in the West Coast is not necessary.

Where coir is not made from coconut husk, this may be buried in the gardens, in shallow trenches 6 feet wide and 1 to 1½ feet deep, opened in between the coconut rows. A layer of coconut leaves may be laid at the bottom of the trenches and the husks spread over it, with the hollows upward and covered with the excavated soil. The whole garden can be covered with husks in the course of 3 or 4 years. The husks absorb moisture during the rainy season and release it for use by the trees during summer, acting as an effective water shed. The beneficial effects of the husks last for 8 to 10 years.

Intercultivation. Coconut gardens are intercultivated with ploughs and light harrows or dug with spades. Intercultivation alone, without any manuring, increased

the yield of nuts at the Coconut Research Station, Kasargode by 170 per cent, while the yield of uncultivated check plots went down by about 7 per cent. Intercultivation of coconuts may advantageously be done 3 or 4 times during the course of the year.

Harvesting. Coconut comes to bearing in 8 to 10 years after planting and it is in full bearing after another 5 years in fertile lands. The bearing may be 3 to 5 years later in poor lands. The nuts are harvested at different intervals in the various localities. In West Coast, 6 to 12 harvests are done in a year. The harvest of fully mature nuts gives the maximum copra and oil. When the nuts are fully mature, the husk is too coarse for extraction of fibre. Where coir is made from the husk, the nuts are harvested when they are green in colour, one month before the time of full development and maturity. The quality of copra and the quantity of oil produced is therby reduced to some extent, but this is made up by the value of the husk. The following percentage composition of coconuts in different stages of maturity shows how the copra and oil content increases with maturity.

Stage of nuts	Average weight	Juice in nut	Shell	Wet meat	Dry kernel	Oil
Tender	476 gm.	24·83	26·62	48·46	18·45	9·50
Mid - ripe	467 ,,	18·20	28·91	52·93	26·80	15·42
Ripe	488 ,,	14·14	27·32	58·26	32·32	19·70

Trained people climb on coconut trees with a flexible fibre ring round their ankles, for harvesting nuts.

The maturity of the nuts is judged by the climber, by tapping them with the back of his knife. The fruit bunches are severed by cutting the stalk near the point of its attachment with the tree, when they drop on the ground. When harvesting is done once a month, one bunch alone is harvested each time from the trees. When the interval is longer, 2 or 3 bunches are harvested. A tree may be expected to produce 30 to 50 nuts per year on an average. The crowns on the tree are cleaned of dry leaves, leaf sheaths and spathes at the time of harvest. When leaves are required for thatching houses, one or two green leaves are cut from the base of the crown of each tree. This will affect the yield of nuts. Tender nuts and seed-nuts are lowered to the ground after harvest with ropes, to prevent their breakage and damage.

Copra. Copra is dried coconut kernel. It can be made from freshly harvested nuts, or nuts kept in storage for 2 to 3 months. During storage, the husks dry up, and there is an increase of 3 to 5 per cent in the copra and oil produced.

Ball copra. Coconuts that are fully mature and that have dry husk are harvested and kept in storage on raised platforms for periods of 8 to 12 months, when there is slow dessication and the 'water' inside the kernel is completely absorbed. The kernel shrinks, gets detached from the shells and rattles on shaking. The shell is then broken carefully, when the kernel is released in the form of a ball, called 'ball copra'. The copra is clean, white inside and sweet to taste. The ball copra made in Malabar and Mysore is exported to North India, where it is in demand.

Cup copra. These are produced for milling and extraction of oil. The coconut is broken into two halves, the 'water' inside is drained and the broken halves are dried, with the kernel exposed to the sun. The kernels shrink in the course of 2 or 3 days and get detached from the shell. They are further dried for 5 or 6 days. Copra made in cloudy weather or during rains gets discoloured and mouldy, and cup copra is not made during rainy months. The nuts harvested during these periods are kept in storage and made into copra later. Artificial driers are used in some countries for making copra during rainy weather and superior quality copra is produced.

Dry copra absorbs moisture from humid atmosphere and is likely to get spoilt during wet weather. It is, therefore, kept in air-tight godowns and dried in the sun periodically, till it is milled. Six to eight thousand nuts give a ton of copra on the average.

Desiccated coconut. This is made in Ceylon and exported to other countries. The product is white in colour, sweet to taste and nutty in flavour. It is used in making confectionery. It can be used in place of fresh nuts for culinary purposes. Coconuts kept in storage for about a month are dehusked. The fresh kernels are detached from the shell with suitable machinery and the brown outer skin is pared. They are washed in tanks and passed through grater, shredder or special cutters, according to requirements. The cut material is dried at 160° to 180° F. The dry produce is sifted, graded and packed in lead lined cases.

Tapping. The tip of the unopened flower bunch or spadix is sliced at the tip and the cells at the cut end are ruptured by tapping with a rod. A thin slice at the tip of

the spadix is removed every day and the tapping is continued. A clear sweet juice oozes out after 3 weeks and it is collected in mud pots. When the pot is coated with milk of lime every day before use, the juice obtained remains sweet and it is called 'sweet palm juice', *'neera'* or 'sweet toddy'. It is a refreshing beverage. It is also boiled and made into raw sugar, called 'palm jaggery'. When the collecting pot is not coated with lime, the juice undergoes fermentation even during collection and it is used as a cheap alcoholic beverage, called 'toddy' or 'fermented palm juice'.

The flow of palm juice from each spadix continues for about a month. The unopened spadices are tapped one after another successively and juice is obtained continuously. The flow of juice is maximum, 3 months after commencing tapping. Tapping is, however, confined to the rainy months only, in coconuts grown under rain fed conditions. Tapping of individual trees is done for a period of 4 years and then discontinued. It improves the bearing of poor bearing trees, but is without effect on heavy bearing trees.

Coir production. The production of coconut fibre or coir from coconut husk is an important industry along the West coast regions and it provides employment for a large number of people. The fibre is enmeshed in pith and is separated by striking the husks with wooden mallets. It is also produced from husks retted in the back waters along the sea coast, by steeping them for a period of about 9 months. Fibre produced from retted husk is of superior quality. It is cleaned, dried and twisted into yarn by hand or with machinery. The yarn is used for making ropes, matting, bags, nets etc.

Under-planting. Coconut gardens start declining in yield after about 60 years, when seedlings can be interplanted between old trees. The old trees compete with the young seedlings and check their growth. The young seedlings are, therefore, manured heavily and kept growing vigorously. The old trees are cut, when the young trees start bearing, as otherwise their bearing is kept down.

Under-planting is sometimes done, when trees are 30 to 40 years of age. There is then considerable competition between the old and the young trees, and since both bear nuts, the old trees are kept on unduly long. There is consequent over-crowding and the object of under-planting, that is, the regeneration of the garden is lost and nothing is gained thereby.

VIII. 7 - Miscellaneous oil seeds.

1. Niger (*Guizzotia abyssinica* Coss.); Tamil - pey yellu; Telugu - verri nuvvulu; Kannada - hutchellu; Hindi - ram til.

Niger is an oil seed crop of minor importance that is grown only in certain regions, as in parts of Visakhapatnam, North Arcot, South Arcot, Chittoor and Cuddapah districts. Small quantities of niger oil were being exported to the United Kingdom, Germany, Austria, France and Italy previously. The oil is used for cooking and the cake for feeding stock.

Niger is grown on light poor soils and in hilly areas. It is rotated with millets like *ragi, samai* etc. It is mixed with horsegram in North Arcot district and with indigo and mustard in South Arcot. It is cultivated like other dry crops, but without any manuring or after cultivation.

It is a short duration crop of 3 months and is sown in July-August. Five to 6 lb. of seed are sown in an acre. The average yield of niger is 300 lb. of seed per acre. The seed gives 35 per cent of oil on crushing.

2. **Mustard** (*Brassica juncea* Coss.); Tamil - kadugu; Malayalam - katuku ; Telugu - avalu ; Kannada - sasive ; Hindi - rai.

Mustard is an important oil seed crop in North India, cultivated in fair areas. The oil is used for cooking and lighting. The seed is used as a seasoning alone in South India. The crop is grown in very limited areas in the Nilgiris, like other dry crops. An yield of 300 to 400 lb. of seed is obtained.

3. *Bassia latifolia* Roxb., Tamil - iluppai ; Telugu - ippa ; Kannada - ippi ; Hindi - mahua.

Iluppai is a big tree and the seeds produced contain 50 to 55 per cent of oil. The oil is inedible and was largely in demand for lighting, before the advent of kerosine. It is now used for lighting in rural areas, temples and places of worship, but by far the commonest use is for the manufacture of soap and candles. The cake is not edible and is used for cleaning the body during oil bath, like soap nut.

4. *Calophyllum inophyllum* Linn., Tamil - pinnai ; Telugu - ponna ; Kannada - vuma ; Hindi - moola and sultana champa.

Pinnai is a vigorous tree, which is commonly found growing by the side of water courses. The seed kernels contain 50 to 53 per cent of oil, which is used for lighting and for the manufacture of soap. The oil seed cake is used as manure.

5. **Neem** (*Melia azadirachta*, syn. - *Azadirachta indica A. Juss.*) Tamil - vembu ; Telugu - veppa ; Hindi - nim.

Neem tree is grown for shade in house compounds and on road sides. Its seed contains 23 to 30 per cent of oil. The oil has good laxative properties and is sometimes used by asthmatic people. Wounds and sores on animals are dressed with neem oil to serve as repellant for keeping off flies. It is used to some extent in the manufacture of soap. The cake is used as manure.

6. *Pongamia glabra* Vent., Tamil - pungam ; Telugu - kanuga ; Kannada - honge; Hindi - kurung.

Pungam is a leguminous tree that is grown on tank bunds and along channel courses for the production of green leaf manure. Its seed contains about 27 per cent of oil. The oil is used for dressing wounds, scabies, etc., and for the manufacture of soap. The cake is a valuable manure.

CHAPTER IX

MISCELLANEOUS FOOD CROPS

IX. 1—Banana (*Musa sapientum* L.)

Vernacular names. Tamil - vazhai; Malayalam - vazha; Telugu - aratti; Kannada - bale; Hindi - kela.

Origin. Banana is one of the oldest fruits under cultivation in India and is referred to in ancient Hindu literature and epics in India, as a remarkable fruit, and as the fruit of the sages by Greek, Latin and Arab authors. Various views are held about its original home by different investigators. Most banana varieties may be considered to be derived from *Musa acuminata* and *M. balbisiana,* which have originated in Asia, including India, as all the varieties have many hybrid characters derived from these two species. *M. superba* (*Ensete superbum*) Roxb., the ornamental banana is of Indian origin. *M. banksii,* a species close to *M. acuminata* and supposed to be confined to New Guinea and Queensland has been recorded by Gopalan Nayar to have been found in the Singampatti hills (Tirunelveli district), in a wild state. The wealth of banana varieties in India, more particularly in Malabar, is unequalled by that of any banana region in the world. It looks probable that India is, at least, one of the original homes of the banana. *M. textiles* Nee., an outstanding species, is cultivated mainly in the Phillipines, for its fibre and is not to be found in India in its natural state.

Adaptation. Banana is essentially a crop of the tropics and ranks first in commercial importance among tropical fruits. Its cultivation on a commercial scale is confined to 30° on either side of the equator. It is partial to heavy rainfall regions like Assam and the Malabar coast. It is cultivated as a rain-fed crop in areas of moderate rainfall, when it is evenly distributed as in the Palni Hills. It is grown on a commercial scale even in regions of moderate and low rainfall in South India, where there are adequate irrigation facilities as at Tiruchirapalli, Tanjore and parts of Coimbatore and Tirunelveli districts.

Banana is cultivated on a large scale all over the world at low elevations, from sea level to an altitude of 1,500 feet above, where the mean temperature is 75° to 85° F. Certain varieties are capable of adapting themselves to higher elevations also. Thus, the 'Poovan' variety comes up well at an altitude of 3,500 feet in the Nilgiris, the 'Virupakshi' in the lower Palni Hills at an altitude of 3,200 to 5,500 feet and the 'Sirumalai' banana in the Sirumalai Hills at 2,500 to 5,500 feet. Varieties like 'Karun Kadali', 'Chen Kadali', 'Krishna Vazhai', 'Ney vazhai' and 'Monthan' come up well in these high altitudes in South India. The bulk of the banana crop in East Africa is grown at an altitude of 4 to 5 thousand feet, with the range of cropping extending from sea level to an altitude of 7,500 feet, with a mean temperature of 50° to 60° F.

Rich loamy soils with facilities for drainage are ideal for banana. It has a restricted root zone and adapts itself to wet land areas and shallow soils, and yields heavy crops. It thrives in a variety of soils as the loamy clay

soils of the Tanjore delta, the heavy clays of the Godavari delta, the fertile loamy slopes of the lower Palni Hills, the deep red loams of the lateritic type along the West Coast, the extensive sandy tracts of Bassein district and the black loamy areas of Kandesh district of Bombay, and the Gangetic alluvia in the Hooghly dlstrict of West Bengal.

Distribution and world trade. The most important banana region in the world is around the Carribean Sea, comprising Jamaica, Honduras, Coasta Rica, Guatemala, Mexico, Panama, Cuba and Nicaragua, in the order of importance. The crop is cultivated on a large scale in Florida in North America, Brazil, Colombia and Equador in South America, throughout Equatorial Africa, in Uganda, Zanzibar, Cameroons, French West Africa, Ivory coast, Mozambique and Eritrea. In Asia, India is the chief producing country and the produce is utilised entirely for internal consumption and there are no exports. Malaya, Ceylon, South China, Formosa, Fiji, Java, the Phillipine Islands, Western Samao and Queensland are the other banana producing countries.

The extent under banana in India is estimated to be about 4 lakhs acres, out of a total of 20 lakhs acres under fruits. Madras, Travancore-Cochin, Andhra, Bombay, Mysore, Assam, West Bengal and Bihar are the chief regions of banana production in the order of importance, as seen in the next page.

Malabar has a large area under banana. Madurai, Tiruchirapalli, Tanjore, Coimbatore, Tirunelveli, South Kanara, Salem, Godavari, Visakhapatnam and Srikakulam are important centres of banana cultivation.

Extent of banana cultivation in the important States in India.

Name of State	Extent in acres
Madras	138,130
Travancore - Cochin	49,000
Andhra	22,190
Bombay	21,940
Mysore	21,000
Assam	19,500
West Bengal	12,000
Bihar	11,800

The normal extent of banana cultivation in the various districts of the Madras and Andhra States is given below:

MADRAS		ANDHRA	
District	Extent in acres	District	Extent in acres
Chingleput	1,910	Srikakulam, Visakhapatnam	4,570
South Arcot	1,620	East Godavari	6,580
North Arcot	1,460	West Godavari	6,630
Salem	4,450	Krishna	540
Coimbatore	5,390	Guntur	980
Tiruchirapalli	13,870	Kurnool	260
Tanjore	12,640	Anantapur	100
Madurai	18,060	Cuddapah	530
Ramanathapuram	2,370	Nellore	980
Tirunelveli	8,280	Chittoor	750
Malabar	60,410		
South Kanara	7,660		
Nilgiris	750		
Total (Madras)	138,870	Total (Andhra)	21,920

Season. The season for planting banana varies from tract to tract depending upon the distribution of rainfall, irrigation facilities and the market demand. The demand for fruit is almost constant throughout the year, except during the marriage season like July-August, when it is

high. Monthly planting trials made with the 'Poovan' and 'Monthan' varieties at the Central Banana Research Station, Aduthurai indicate that banana can be planted in all months, except during summer from February to May. Plants set during the cold months in December-January are not likely to establish properly and make vigorous growth in all places, as in the Circars. Planting can be done any time from June to November throughout South India. But, certain planting seasons are recognised in the different regions, based on local experience, when the best growth may be expected. In Malabar, 'Nendran' suckers are planted in May-June and this enables them to get established before the commencement of the south-west monsoon. Planting is also done when the north-east monsoon commences. In Tiruchirapalli, *Adi pattam* (June-July) is the season most favoured for planting banana, as the bunches then get ready for harvest during the marriage season in July-August of the following year. In the Circars, June plantings are favoured for 'Vamana Keli', 'Chakra Keli' and 'Monthan' varieties and November-December plantings for 'Karpura Chakra Keli'. In South Arcot, the planting season for 'Mauritius', the dwarf variety, is July-August. The plants make vigorous growth during the north-east monsoon season and the entire crop is harvested within a year. Fresh plantings of 'Virupakshi' and 'Sirumalai' hill banana are done in November-December.

Varieties. Banana may be classified broadly into two groups, comprising (1) the dessert varieties and (2) the cooking varieties. Both go by the name of banana. The dessert varieties are consumed when the fruits are ripe, in the raw state. The unripe fruits of the culinary

varieties are cooked and used as vegetable and they are sometimes called 'plantains', specifically.

There are a large number of varieties of bananas in South India. The same variety may go by different names in different places and sometimes the same name may denote different varieties in different places. Thus, the name 'Rasthali' given to a particular variety in Tiruchirapalli is synonymous with 'Mutheli' in Bombay, 'Rasa Bale' in Mysore, 'Poovan' in Malabar and 'Amirthapani' in the Circars. The same name denotes another variety in Tirunelveli and it goes by the name of 'Chakra Keli' in the Circars. The existing nomenclature is very confusing; it stresses the need for assembling and maintaining all the available varieties in one place and reducing all synonyms to single standard names.

Among the world's dessert varieties, the 'Gros Michel' or the 'Jamaican banana' takes the first rank, combining many desirable qualities remarkably, as quality fruits of good length, flavour, attactive skin colour, resistance to bruising, grade, yield, and symmetry and strength of bunches. It is produced mainly in the Caribbean Islands and Central America. When the bunches are harvested at the three-fourths mature stage, it stands refrigerated transport for 2 to 3 weeks, from the Caribbean region to the United States of America, Canada, England and Europe. It has been tried on an experimental scale in a number of places in South India and found to come up well and give heavy bunches, with a slight fall in the size and quality of the fruits. It is affected by adverse seasonal conditions, insufficient and untimely manuring and fall in standards of cultivation. It is, however, not a hardy variety and is susceptible to wilt or the 'Panama disease'. It is being replaced slowly by another variety,

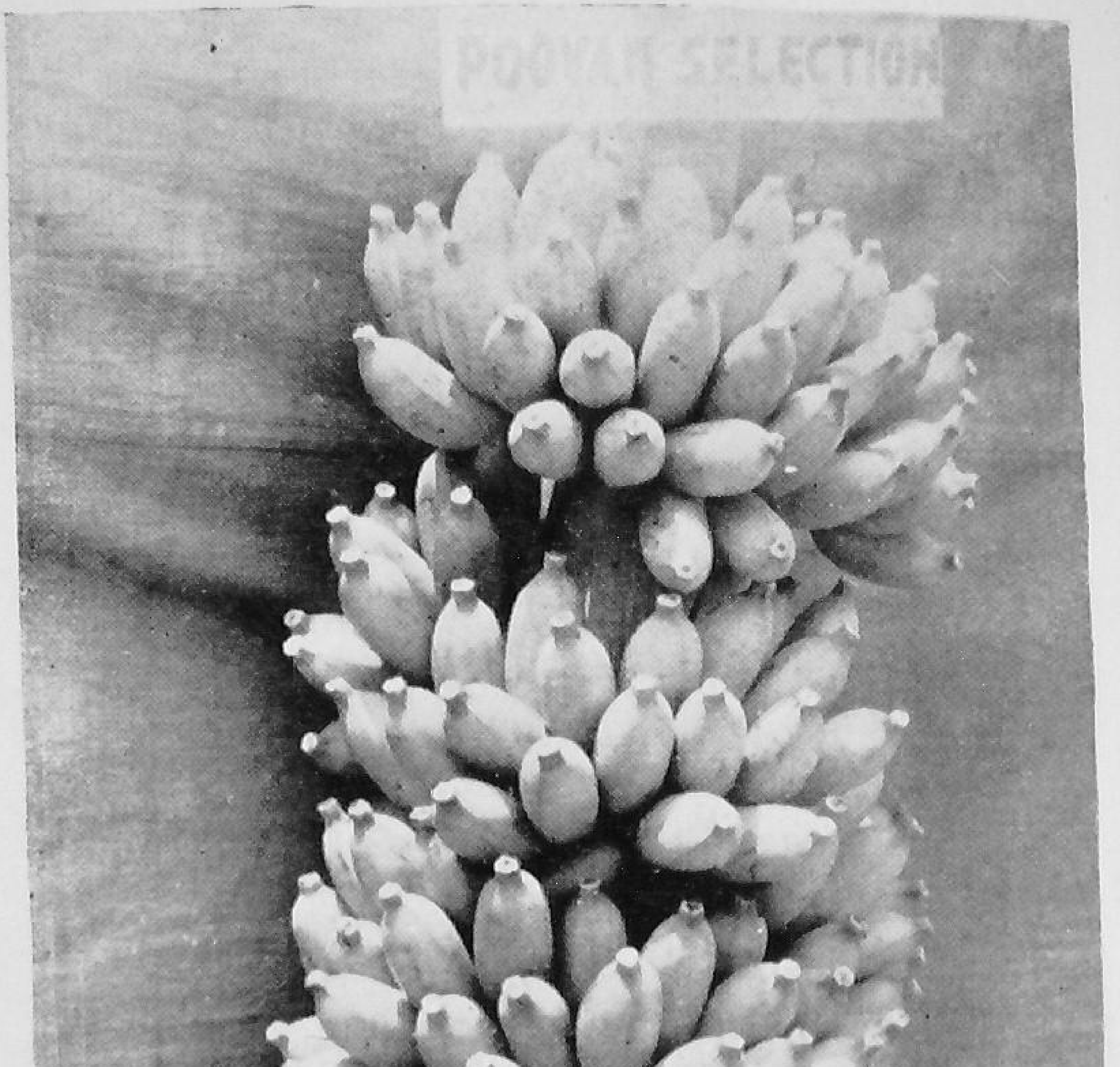

FIG. 32. A good 'Poovan' banana bunch.
—*Courtesy: Banana Research Officer, Aduthurai*

called 'Lacatan', a tall member of the Cavendish group originated in the Phillipines and highly resistant to wilt. The latter produces heavy bunches and fruits, which are, however, lower than 'Gros Michel' in grade.

The Cavendish group of bananas, known more commonly as 'Dwarf' bananas, are second in commercial importance, based on world export figures. They are grown in Florida, the Canary Islands, East Africa, Locatan in Phillipines, Queensland and India. Outside these, the other world varieties are (1) the 'Lady Finger", the second commercial variety of Australia and the Phillipines, which resembles the 'Pacha Nadan' of Madras and (2) the 'Martaban' of British Guiana. It is the same as the 'Rasthali' of South India, which was possibly introduced into India by emigrational labourers. The other commercial varieties produced in the different countries are more or less identical with 'Gros Michel' or the Cavendish group.

The important commercial varieties of banana in South India are 5 in number, namely (1) 'Poovan', (2) 'Monthan', (3) 'Pacha vazhai', (4) 'Rasthali' and (5) 'Hill banana'.The first four are widely distributed all over India and the fifth is confined to South India.

1. Poovan (Madras), Syn: 'Champa' in West Bengal, 'Karpura Chakra Keli' in the Northern Circars, 'Lal Velchi' in Bombay, 'Dora vazhai' in the Nilgiris, 'Palayamkodan' in Malabar and 'Mysore' in Trinidad. It is the foremost commercial variety in Madras, Andhra and West Bengal districts. It is hardy and is popular with growers. It makes vigorous growth under the perennial system of cultivation in Tanjore. It comes up equally well in wet lands and garden lands here, as in other countries and has a cosmopolitan habit. The

bunches are about 30 lb. in weight on the average in good plantations. The fruits are of medium size and keep well. The rind is thin and golden yellow in colour with a rusty red tinge. The pulp is cream coloured and has a distinct subacid taste. The variety is resistant to the 'Panama' disease. It is estimated to occupy 70,000 acres in Madras State accounting for three fourths of the marketable bananas.

2. *Monthan* (Madras) - Syn. 'Kanch Kela' in West Bengal, 'Madhuranga Bale' in Mysore, 'Bontha' in Andhra, 'Ponthan' in Malabar and 'Bainsa' in Bihar. It is the foremost culinary variety in the Indian Union. It is hardy and resistant to drought to an extent. It is in demand as a vegetable right through the year and is preferred for commercial cultivation. The fruit bunches are heavy and pendent, with fruits and the hands loosely set on the peduncle. The ripe pulp is cream coloured, flat and insipid. The fruit rind is thick and green. 'Monthan' occupies 9 per cent of the estimated area under banana in Madras and ranks third in commercial importance.

3. *Pacha vazhai or Mauritius* (Madras) - Syn: 'Basrai' in Bombay, 'Kabulee' in West Bengal, 'Jahaji' in Bihar, 'Kuzhi vazhai' in Malabar, 'Vamana Keli' in Andhra, 'Bhusaval' in Hyderabad, 'Nyora' in East Africa and 'Mons Marie' or the 'Chinese' banana in Australia. It is a dwarf type belonging to the Cavendish group of bananas. It is hardy and is under cultivation in all the banana regions of the world. It can be safely grown even in regions subject to strong winds, where the tall types are at a disadvantage. It does not spread out the foliage like the tall type and it is, therefore, planted closer, with a

larger number of plants in unit area. The fruits retain the green colour on the thick rind even when they are ripe, though types like the 'Basrai' of Bombay turn yellow on ripening. They do not keep well and cannot be transported over long distances. The fruits are long and the bunches are heavy. The pulp is fairly sweet, dull white in colour, soft in consistency or mushy, and of medium quality.

It is grown on a commercial scale in South Arcot district and its cultivation is spreading slowly in Tiruchirapalli, Tanjore, Tirunelveli, Malabar and Chingleput districts. It is the leading commercial variety in Bombay and second in importance among the varieties in Bengal.

4. Rasthali (Madras) - Syn: 'Mutheli' in Bombay, 'Poovan' in Malabar, 'Amirthapani' in Andhra, 'Rasa Bale' in Mysore, 'Martaman' in West Bengal and 'Martaban' in British Guiana. It is a choice table variety and is given the first rank among bananas in South India, by some. It is costlier than other bananas in all the Indian markets. It has a good root system and is able to resist wind to some extent. The fruits are like those of 'Poovan' in general shape and size, but more rounded and pale. The fruit rind is thin and develops an ivory yellow colour on ripening. The flesh is white, rather firm, very tasty, sweet and pleasantly flavoured. Its main drawbacks are susceptibility to wilt and dropping of the ripe fruits from the bunches. Sometimes, big sized fruits develop a stony lump in the pulp, which is said to be eliminated when the bunches are held in cold storage.

5. Hill bananas - ('Sirumalai' and its eco-type 'Virupakshi'). The latter is sometimes referred to as

'Kannivadi' and 'Vella vazhai'. The 'Sirumalai' banana is cultivated in the Sirumalai Hills. It is considered to be the top quality fruit among South Indian bananas and 'Virupakshi', cultivated in the lower Palni Hills, is a close second. They have firm flesh and keep better than other varieties. They are popular with consumers and are marketed in all the important towns in South India. This distinction is not shared by any other South Indian variety. When these are cultivated in the plains, the quality falls down to the level of 'Pacha Nadan'.

There are a number of other varieties of banana in South India, grown in small areas here and there. Mention may, however, be made of a few of the more important ones. 'Nendran' is a special variety of Malabar, which is both a dessert and a culinary variety. The pulp is yellow with a characteristic flavour. The ripe fruits keep well for over 15 days. There are a number of sub-varieties and a sport form, called 'Moongil' develops only one or two hands of giant sized fruits. 'Pacha Nadan' is a semi-commercial variety, which is superior to 'Poovan' in quality. 'Nanguneri Peyan', 'Ney Mannan' or 'Vayal Vazhai' is a popular culinary variety, cultivated in the region south of Tiruchirapalli. It is preferred to 'Monthan' in this tract. The ripe fruits are flat and insipid. 'Kunnan' is a superior dessert variety of Malabar. Unripe 'Kunnan' fruits are sliced, dried in the sun and ground into flour, for use as infant food. A sub-variety, called 'Adakkai Kunnan' has fruits resembling arecanuts in shape and size. 'Thane Kunnan' is a special variety with delectable fruits of superior quality and extremely sweet taste. 'Ney Poovan' is another superior variety of Malabar. 'Red Banana' has red coloured pseudostem and the rind of the fruit is also red. The

pulp is mushy with a strong characteristic flavour. It is considered to be on par with 'poovan' by some and to be a superior variety by others. It is one of the few varieties distributed all over the world. 'Peyan' is a tall variety, which is under stray cultivation in house compounds and perennial banana areas. The fruits have an ashy coat and a peculiar taste, which is relished by some people alone. They have the repuation of being able to soothen the bowels and give some relief against piles. 'Poovilla chundan' is a popular dessert variety, which is slowly becoming a semi-commercial variety in Tirunelveli. The fruits are of medium size, with a thin rind and a sweet creamy pulp. There are a limited number of functionally pistillate flowers and all of them set into fruits. There are no neuter or staminate flower clusters and no pendent inflorescence cones below the hands of fruits, as in other varieties. 'Manoranjitham' is a medium-tall slender plant with a conspicuous black coloration of the pseudostem and small sized thick rinded angular fruits, which are of medium quality and have a strong flavour. 'Chakra Keli' or 'Nalla Chakra Keli' of the Circars is a superior variety with good quality fruits. Stray plants are grown in betel vine gardens in Tamil Nad and they go by the name of 'Thane Kadali', 'Raja Bale' and even 'Rasthali' in different parts of South India. The bunches are small in size and loose. The fruit rind is thick and the pulp is creamy yellow. It is cut across and the pulp is squeezed out for consumption. It is considered to be the tastiest banana by some people.

Rotations and mixtures. Banana requires considerable moisture for its growth and it is, therefore, cultivated extensively in wet lands alone. It is kept on the land for 3 years. The first crop of bunches is harvested towards

the end of the first year. Surplus suckers are then removed, leaving behind one or two suckers alone in each stool and these 'followers' give the next crop of fruit bunches after a period of 9 months. Afterwards, all the suckers in the gardens are allowed to develop and the leaves produced are harvested periodically during the third year. The land is cleared at the end of 3 years for the next crop of rice, sugarcane, or sometimes turmeric. The sequence of crops and the frequency of cultivation of banana on the land vary from tract to tract and holding to holding, depending upon the conditions prevailing and the facilities available. In certain small holdings, rice and sugarcane occupy the land for 2 years and these are followed by banana. Banana is not ordinarily grown at such frequent intervals. In Malabar, Tiruchirapalli and parts of South Kanara, the 'Nendran' banana is kept on the land for one year only and this is followed by rice, sweet potato (or tapioca) and later by rice. In South Arcot, the dwarf type of banana is cultivated extensively and uprooted at the end of one year, like 'Nendran', without ratooning it as with other varieties of banana, and followed by sorghum and chilli, or *ragi* and groundnut, in garden lands.

The cultivation of arecanut and banana as a mixture permanently is a common feature in Puttur taluk in South Kanara district. One banana sucker is planted between two arecanut plants, which are 12 to 14 feet apart, and there are 220 to 300 arecas per acre and an equal number of banana clumps. Only certain varieties of banana like 'Ney Poovan' and 'Boothi Bale' are interplanted in arecanut gardens. The banana keeps the surface of the oils shaded and cool. The clumps are desuckered judiciously and the 'followers' are carried

forward for about 25 years, that is, till the gardens are taken up for under-planting arecanuts. The arecanuts and bananas are splash watered together, and the bananas are not manured. In parts of Malabar, Coimbatore and Tanjore, mixed cropping with coconut, arecanut and banana is common on the flanks of rivers. Bananas can be raised on mounds in ill drained areas and the low lying areas cropped with rice, as is being done at the Central Banana Research Station, Aduthurai.

Cultivation in wet lands. The method of preparing the land and cultivating banana varies with the type of land. High level areas in wet land regions, which have facilities for drainage, are selected and ploughed 4 or 5 times preliminarily. Cattle manure, or sometimes compost, is applied one month before planting banana, at 30 cart-loads per acre and covered by ploughing. Water is let into the fields at the time of planting for moistening the clods and drained immediately, as at Tiruchirapalli. Pegs are planted in the fields 7 feet apart and three months old banana suckers are planted at the peg sites, by scooping out a little earth. The suckers are fixed by heaping moist clods all round and compacted by pressing with the foot. An acre accommodates 890 plants.

In high level wet lands in Malabar, trenches 2 feet wide and 1 foot deep are opened 7 feet apart, after ploughing the land preliminarily. Three months old 'Nendran' suckers are removed from ratoon crops, wilted* for a fortnight after smearing them with ash and a thick suspension of cow dung in water, and planted. The suckers are spaced 6 to 7 feet apart along the trenches and 890 to 1,040 suckers can be planted in an acre. They are manured with ash and green leaf at intervals of 6 weeks

* Wilting promotes rooting in woody stem cuttings also.

and this fills up the trenches gradually. In areas subject to stagnation of water, 'Nendran' suckers are planted on mounds 3 feet high and 3 feet wide at the base, 7 to 8 feet apart, with 890 to 680 plants per acre. Alternatively, drainage channels 2 feet wide and 3 feet deep are opened 7 feet apart and the intervening strips are raised with the dug-up soil. The raised strips are one foot above the level of water that stagnates during rainy weather. Pits 1½ feet cube are dug on the raised strips, 7 feet apart, and 'Nendran' suckers are planted.

Manuring and aftercultivation. Of the suckers planted, some fail to establish and the gaps are filled up, as they are noted. Banana requires clean cultivation and the fields are dug with spades 4 to 6 times in the year, commencing one month after planting. The land is next dug 2 to 3 months after planting, basins are formed round the plants, the first dose of manure is applied and followed by the earthing-up of plants. It is important that the soil should have sufficient moisture at the time of the application of the manure. The application of 1 lb. 4 oz. of ammonium sulphate and 50 lb. of cattle manure, or 3 lb. of groundnut cake to each plant, supplying 0·5 lb. of nitrogen, split into 2 doses, at 2 to 3 months and at 5 months respectively after planting, have given good results at the Central Banana Research Station, Aduthurai. Groundnut cake can be substituted by other oil cakes on an equal nitrogen basis. Five pounds of neem cake and 3 lb. of groundnut cake contain an equal quantity of nitrogen and either the one or the other can be applied. The particular soil is fairly rich, and poorer soils may require more nitrogen. Where soils are deficient in potash as in Malabar, application of 25 lb. of wood ash or 8 oz. of potassium sulphate per plant is

necessary, in addition to the above. Phosphate deficiency can be made up by the application of 8 oz. of superphosphate per plant.

After the first application of manure, trenches 2 feet wide and 1½ feet deep are opened with 2 rows of bananas in between. The soil removed from the trenches is used for earthing-up the plants. Sometimes, trenches are dug both length and breadth-wise, with 4 plants in each mound and trenches all round. Four to five months after planting, that is, about 2 months after the first manuring, the entire area is dug again, basins are formed round the plants as before, suckers are removed and the second dose of manure is applied. The trenches are deepened at the time and the plants are earthed up again. This assures adequate drainage.

Manuring is done more intensively in countries like Jamaica, where the cultivation of banana has become specialised and proficient. One pound of nitrogen (=5 lb. of ammonium sulphate) is applied to each clump consisting of a parent plant and a follower sucker, annually. It is split into 4 to 6 doses and applied at suitable intervals, as it is quick acting and its effects last only for a short time. A regular supply of nitrogen and maintenance of nitrates in the soil at an even level throughout the life of the banana plant gives the best results. The number of fruits on each hand and the number of hands on each bunch are influenced by the condition of the plant, early in its life. The application of the first dose, both regarding quantity and time, is therefore of considerable importance. Subsequent application of manure, even in large quantities, is without effect on the number of hands and fruits produced. But it influences the length and

girth of fruits and gives the necessary initial stimulus to the follower. The Jamaican soils are not deficient in phosphorus and potassium, which are not supplied in the manure.

In regions subject to heavy wind, the banana plants have to be propped up with bamboos. The bamboos are secured to the pseudostems, just below the crown. The prop rests on the ground and supports the heavy crown. Though the plants may swing to and fro with the wind, they seldom break or fall down.

Banana suckers spring up from the corms or the true underground stems off and on, throughout the life of the banana plants and they have to be removed periodically. This is called 'desuckering'. When the mother plant flowers, one sucker alone is retained as the 'follower' and the others are removed ; this is found to be better than the other systems of desuckering. Desuckering is done with the object of conserving the nutrients in the soil for the proper nutrition of the mother plant and the follower. Otherwise, their growth and productivity are affected adversely. Desuckering is sometimes done at wide intervals, after the suckers make considerable growth, which is not fully advantageous.

Desuckering can be done with crowbars, which are about 4 feet long, flattened and sharpened like chisels to a width of 4 to 5 inches. Smaller crowbars with 3-inch edges can be used for removing small suckers. A more efficient tool is a half inch round iron bar, $1\frac{1}{2}$ feet long, with one end sharpened to a half inch chisel point and the other end bent for providing leverage and grip for handling. The unwanted suckers are cut flush with the

ground. The chisel point of the tool is then pressed down at the centre of the cut end and rotated slightly, to inactivate the bud, without injuring the rhizome below. Inactivating the bud is better than desuckering, and removing a bit of the rhizome and the roots attached to it, which gives a shock to the plant and interferes with assimilation for a time.

Cultivation in garden lands. It is not essentially different from wet land cultivation. The land is ploughed 4 or 5 times, after the harvest of the previous crop, manured with cattle manure at 20 to 30 cart-loads per acre and pits are dug for planting suckers. The pits are $1\frac{1}{2}$ ft. x $1\frac{1}{2}$ ft. x $1\frac{1}{2}$ ft. in size and 6 feet apart, for planting dwarf bananas in South Arcot district, during July-August. Tall bananas are planted similarly in garden lands at Coimbatore, but the pits are 1 foot cube and 8 feet apart, with 680 pits to an acre. Three months old suckers are separated from ratoon crops and wilted for a number of days before planting. Beds are formed and the land is irrigated once in 7 to 10 days during the first 5 months and once in 10 to 15 days, later. Drainage is not a problem in garden lands and elaborate arrangements are not needed here, as in wet lands.

Cultivation of perennial banana in the Cauvery delta. Banana is cultivated as a perennial crop in high level lands in the Cauvery delta region, called '*padugai*' lands, over an area of 11,000 acres and some plantations are over 50 years old. The soils have been formed by the deposition of silt from the Cauvery River and are rich naturally. The supply of water to wet lands, from late June to early February, provides sufficient moisture for the *padugai* lands, as the wet land channels run between

them. The banana depends on the moisture in the subsoil and that supplied by the rains from February to June, when the channels are closed. 'Poovan' and 'Monthan' are the main varieties grown, with a sprinkling of 'Peyan' and 'Rasthali'. When new plantations are started, banana suckers are planted 11 feet apart, with 360 plants to an acre, in December-January, after digging the soil thoroughly.

As annual routine practices, the plantations are dug with spades in February and June and also 2 or 3 times later, from August to October. They lie wet during the north-east monsoon season and cannot be cultivated during the period. One vigorous 'follower' and sometimes, a small sucker just emerging from the soil are left behind and other suckers are removed. At the time of desuckering in January, old pseudostems and rhizomes are chopped and incorporated with the soil thoroughly. Some farmers apply 50 lb. of cattle manure, or 25 lb. of silt per clump, at the time of digging the soil in June, after the receipt of water in the channels. The inherent fertility of the soil and the systematic cultural operations done contribute to the maintenance of a high level of productivity in these lands for long periods.

Cultivation of perennial banana in the Palni Hills. The cultivation of banana as a perennial crop on a commercial scale, in about 7,000 acres, on the slopes of the Upper and the Lower Palni Hills in Madurai district is another unique system. The banana fruits go by the name of 'hill fruits', comprising the 'Sirumalai' and the 'Virupakshi' varieties. The cultivation is confined to an altitude of 2,300 to 5,500 feet above sea level. As the cultivation of these bananas is very profitable and as the

demand for the fruits is on the increase now, the area under the crop is increasing gradually at the expense of the less profitable cardamom. Some plantations near Pannaikadu are over 50 years old and continue to be profitable, though the usual life of these plantations is about 10 years normally. The banana deteriorates quickly in poor soils, which are then diverted to coffee.

The hill banana is grown as a rain fed crop on hill slopes, where the average annual rainfall is about 55 inches. A half of this is precipitated during the north-east monsoon season and the other half is distributed almost equally between the south-west monsoon season and the hot weather period. The rich retentive nature of the soil, the systematic cultivation and removal of weeds, the organic material provided by the leaves and the pseudostems, the reduction of transpiration caused by pruning the lower leaves after the plants put out the bunches and the evenly distributed rainfall contribute to the maintenance of a robustness in the banana and of a high level of productivity and profitableness.

The forest slopes are cleared of wild vegetation and laid out in terraces and plots. A good part of the cost of clearing is recovered by the sale of fuel and timber obtained. Pits are then dug and banana suckers, 3 to 4 months old, are planted. They are laid in rows 16 feet apart in the Thandikudi region, with a spacing of 8 feet between the pits in the row, accommodating 340 pits in an acre. Heavy yields are obtained from the third year of planting and 4 plants are left in each clump. Two rows of coffee seedlings are planted in the inter-row spaces between the bananas, during the third year. The banana yield starts declining in about 10 years, when it gives

place to coffee that starts bearing at the time. At Pannaikadu, Perumalmalai and adjoining villages, the spacing between bananas is 11 feet both ways, with 360 clumps to the acre. The 'followers' change the spacing, which is attempted to be maintained at the original level, by judicious desuckering.

The plantations are dug 4 to 6 times in the year and maintained in a clean condition. At the time of digging each time, dry leaves and leaf sheaths are removed from the plants, the old rhizomes and pseudostems are chopped and incorporated with the soil. Desuckering is also done methodically. The number of followers left behind in the clumps and their age are so regulated that bunches get ready for harvest steadily in the plantations right through the year. Considerable experience is required in judging the probable time of bunching of the young suckers. Another important operation is the pruning of all the lower leaves in bananas which have put out the bunches. It assists in reducing the resistance offered by the plants to heavy winds, which might otherwise lodge them, or break their stems, and in making the mature bunches conspicuous at the monthly harvests by the reduction of the foliage cover, besides reducing transpiration, as indicated already.

Most plantations are not manured.. The burial of the various banana refuse is able to maintain the yield at a satisfactory level. When cattle are maintained near plantations, as on either side of the road near Pannaikadu, cattle manure is applied at 25 lb. per clump, in October-November. In certain cases, cattle are tethered in banana plantations and shifted frequently to enable wide areas being manured with the excreta of cattle.

The bunches get ready for harvest 15 months after planting and 3 bunches can be harvested from each clump annually, on the average. In one of the plantations, 31 acres in extent, 16,284 bunches containing 11,66,000 fruits were harvested during the year 1953, from 5,120 clumps. Each acre had 165 clumps and gave 525 bunches containing 71 fruits each on the average, during the year. These were sold at Rs 22/- per 1,000 fruits on the average, with the prices ranging from Rs. 20/- to Rs. 35/-

Harvest. 'Poovan', 'Monthan' and 'Rasthali', the common varieties, throw bunches in 8 to 9 months after planting and get ready for harvest in 11 to 12 months. Early varieties take 80 to 110 days to mature and late varieties 140 to 170 days. The plants put out bunches at different times and the harvest is spread over 3 months. The fruits are disposed of as bunches, in general. The hands are separated from the 'Monthan' and 'Rasthali' bunches in Tanjore and Tiruchirapalli districts, packed in lots of 500 fruits each with dry banana leaves and disposed of in lots. Heavy 'Poovan' bunches with 8 or more hands are sent by rail from Tanjore and Tiruchirapalli to Madras and these are called 'rail bunches'; about 70 per cent of the bunches produced are rail bunches. The smaller bunches, called '*katta vazhai*'', are sold locally.

The bunches are covered with heavy paper or plastic bags during non-rainy periods, in some plantations in Australia, with the object of preventing spots developing on the fruits. These bunches are said to develop uniformly, produce quality fruits of an attractive appearance and to fetch higher prices. The bunches are wrapped with dry banana leaves, about a month prior to harvest, in West Bengal. This costs quarter of an anna

per bunch and is cheap. Spotless fruits, free of rind blemishes and fetching higher prices, are said to be produced as a result of wrapping and worth the extra cost.

The bunches are harvested, when the fruits are fairly mature, before they start ripening on the bunch. Fully mature bunches cannot stand transport and get over ripe before they are retailed. The fruits ripen only gradually on the bunches and do not change colour uniformly. The bunches are usually smoked at the consuming centres, in the godowns of the wholesale merchants and not in the producing areas, though there may be variations even here. Thus, the hill bananas are received at Kodaikanal Road, the consigning railway station, in the afternoons in an unripe state. They are smoked during the night, packed and put on rails the next morning. The fruits change colour during transport and are ripe and ready for retailing, when they reach their destination.

The smoking of banana bunches and/or hands is done in small low roofed rooms, with only one entrance door. The fruits are arranged in the room and the door is closed. A low smouldering fire is started with dry banana leaves packed tightly in a small fire place near the entrance. The smoke fills the room and escapes through a small flue, and the temperature of the room is raised a little. The fire is put out after a time and the smoke entry and exit openings are closed. The fruits are held in the smoking room for 12 to 48 hours, depending upon their stage of maturity; immature fruits have to be held for a long time. Tender bunches, which have not changed colour, are smoked again.

Mattocking. Mattock is a combination tool with hoe and axe edges. The pseudostem of the banana is cut back after the harvest of bunches in stages, over a period of 3 months, as a regular practice in Jamaica. The mother corm is finally cut into pieces and spread round the clumps with the mattock. It is considered advantageous to keep the old pseudostem standing and the mother corm healthy for some time, to enable the follower to withdraw the plant food in the mother corm and make uninterrupted growth.

Yield. The yield of banana is variable. The produce is sold in bunches, hands or fruits individually in retail and these are so variable in size and number that a useful representative idea cannot be furnished with such variables. The number of plants in an acre ranges from 360 to 1,200, with spacings of 11 to 6 feet between plants. The number of hands in the bunches ranges from 5 to 10 ordinarily, with 2 as the minimum and 30 as the maximum rarely. The number of fruits in hands ranges from 10 to 25. The weight of bunches ranges from 8 to 30 lb. each. The weight of the individual fruits is also variable, being about $1\frac{1}{2}$ oz. with varieties like 'Namarai' and 6 to 8 oz. with varieties like 'Monthan' and 'Pacha Nadan'. The ratio of the pulp to the entire fruit is 70 to 90 per cent, being low with thick rinded fruits and high with thin rinded fruits.

Uses. Banana is used as a common vegetable and as a dessert fruit in South India. The fruit is a carbohydrate food, supplying energy; the protein and fat supplied are negligible. The base of the peduncle enclosed by the pseudostem and the inflorescence cone hanging at the end of the bunch carrying clusters of unopened flowers, are

also used as vegetable. After all the fruit hands set, the inflorescence cone is snapped and this is believed to assist the uniform development of the fruits and to reduce the period of development. The banana leaf is used commonly as a plate in South India and food is served on it for consumption. The dry leaf sheaths are split into ribbons and used for securing bamboo props to bananas and for binding packages of banana fruits, betel leaves etc. Narrow and thin ribbons are used for stringing flowers and making garlands.

IX. 2—Tapioca or cassava (*Manihot utilissima* Pohl).

Vernacular names: Tamil - mara valli or yelilai kizhanghu; Malayalam - mara kizhanghu; Telugu- karra pandalam; Kannada - mara genasu; Hindi - mara valli.

Importance. Tapioca is a poor man's food crop and it is used as a partial substitute for cereals to an extent, particularly during lean years. The following statements compare the food values obtainable from the land with tapioca and rice.

1. Food value of tapioca tubers and rice.

Particulars	Tapioca tubers	Rice
1. Duration in months	7 to 10	4 to 6
2. Yield in lb. per acre, in Madras	9,432	1,127
3. Protein in lb. per acre	68	78
4. Carbohydrates in lb. per acre	3,651	892
5. Vitamin B value per 100 gm.	32	20

2. Percentage composition of tapioca tubers and rice. *

Particulars	Tapioca tubers		Rice
	Raw	Dried	
Moisture	59·4	13·0	13·0
Carbohydrates	38·8	82·9	79·2
Protein	0·7	1·5	6·9
Fat	0·2	0·4	0·4
Mineral matter	1·0	2·1	0·5

* Source: *Health Bulletin No. 23*, Nutrition Research laboratories, Coonoor, 1951.

Tapioca produces four times as much carbohydrates from the same area as rice. Such comparisons have, however, their limitations as there are wide variations in the soil, climate and water requirements of the two crops, and fundamental differences in their duration. Yet, there is no doubt that tapioca is a more efficient carbohydrate producer than rice. The tuber is mainly a carbohydrate food and can be used in place of cereals partly, supplementing it with protein. Rice was in short supply during the period of the second world war, and tapioca and fish were the main stay of the poor people in Malabar and Travancore-Cochin. They adjusted their food habits to the food materials available and reduced their privation and suffering.

Origin and distribution. Tapioca is believed to have originated in Brazil, where many allied forms are found growing wild in a state of nature. It has now spread to all the tropical regions, which have a good rainfall distributed over a long period, enabling its cultivation under rain fed conditions. Thus its cultivation is concentrated along the West Coast of India, particularly Malabar and Travancore-Cochin, where rainfall is

abundant and distributed over a long period. Its normal distribution in Madras and Andhra States is as follows:

Madras		Andhra	
District	Extent in acres	District	Extent in acres
Chingleput	860	Srikakulam, Visakhapatnam	1,770
South Arcot	2,290	East Godavari	880
Salem	5,260	Guntur	20
Tiruchirapalli	440		
Coimbatore	160		
Tanjore	580		
Madurai	150		
Malabar	43,770		
South Kanara	510		
Nilgiris	270		
Total (Madras)	54,290	Total (Andhra)	2,670

Tapioca is grown extensively in Malabar and in limited areas alone in other districts. The only other district where it is an important crop is Salem, where it is raised under irrigation and where the tapioca pearl industry has been established in recent years.

Adaptation. Tapioca is cultivated largely in the tropics and to a small extent in the subtropical regions also, at elevations up to 2,500 feet above mean sea level, but it makes vigorous growth in the lower altitudes only.

It thrives in open sunny situations and makes poor growth in shady places. It tolerates drought as well as heavy rains very well, but not stagnation of water. For instance, tapioca planted in December with the last rains of the season in certain cases in Malabar gets established and makes some growth, before summer conditions set in. The young crop survives the trying summer period and commences active growth in the month of May, on receipt of the seasonal rains. It withstands the heavy south-west monsoon rains later. It is grown in subtropical America, having less than 20 inches of annual rainfall. It flourishes in tropical Malabar, where the rainfall is 125 inches during the growing period and thrives in Visakhapatnam, where the rainfall is only about 30 inches during the crop season. Thus, it is adaptable to a wide range of conditions of rainfall. It comes up well under irrigation, but does not tolerate saline water.

Tapioca is cultivated in a variety of soils, like the sandy soils of the East Coast, the laterite loams of Malabar and the red loams of the Central districts. Even the bare hill slopes and waste lands in Malabar and Travancore-Cochin considered unsuitable for the cultivation of other crops are devoted to it, while it is more exacting in its requirements in the richer loams by their side. Clayey and stiff soils do not favour the development of the tubers to the fullest extent and are not preferred for the cultivation of the crop. Further, there is difficulty in digging the tubers in stiff soils and consequent rise in the cost of cultivation. Thus, tapioca is capable of adjusting itself to varied conditions of soil and climate.

The plant and its varieties. It is remarkable that such widely different plants as tapioca, rubber and castor are

members of the same family, *Euphorbiaceae*. Tapioca is an erect shrub, 6 to 9 feet in height, without much of branching. It is propagated by planting stem cuttings, though it can also be grown from seed. It is an annual crop. The roots get modified into tubers by the deposition of starch. The tubers have varying quantities of cyanogenetic glucoside, which hydrolyses and sets free hydrocyanic acid, a virulent poison. The glucoside content of the cultivated varieties is very low, while it is considerable with the wild varieties, which have a trace of bitterness also. The tubers are rendered safe for consumption by cooking, when the glucoside is destroyed. The duration of the cultivated varieties ranges from 7 to 12 months.

There are a number of varieties of tapioca under cultivation. There are differences in the morphological characters, such as the height of the plant, the shape of the leaves, and the colour of the stem, leaves, petioles, tubers etc. The tuber rind colour ranges from white to dark brown and the pulp colour from white to cream.

Cultivation. The land is prepared preliminarily by ploughing 3 to 5 times and brought to tilth. Cattle manure is applied at 15 to 20 cart-loads to an acre almost throughout the country and covered by the last ploughing. This is supplemented by penning sheep at 1,000 per acre at Visakhapatnam. Cattle manure is available to a limited extent alone in Malabar and 4 to 5 cart-loads are applied over an acre and supplemented with 2 to 3 cart-loads of green leaves and 10 bags of wood ash. West Coast soils are deficient in potash and the application of ash is a common feature. In Godavari, ammonium sulphate is applied at 100 lb. per acre two months after

FIG. 33. The tapioca plant.
—*Courtesy: Director of Agriculture, Madras.*

planting the crop, in addition to the cattle manure applied initially. In Travancore, pits dug for planting are filled with dry leaves and burnt to ward off termites. Tapioca is established by planting stem cuttings, called 'sets'. The stems of the previous crop are bundled and kept in shade for use as sets. These can be kept in a condition suitable for planting for about 3 months. The tender top and the basal portions are rejected and the central part of the stem is cut into pieces, 6 to 9 inches long and each stem can furnish 6 to 8 sets. Cuttings up to 24 inches in length are used for planting in other countries. They are planted usually in a slanting position, burying 3 to 5 inches of the stem inside the soil. They can also be planted vertically, or even laid horizontally and covered with soil, 2½ to 3 feet apart each way and 4,840 sets are required for planting an acre with 3 feet spacing and 7,000 sets with 2½ feet spacing. Ten to twenty per cent of the sets do not sprout and reserve sets are planted in nurseries at the time of planting the field to provide rooted cuttings for filling up gaps later.

The crop is weeded and hoed 4 to 6 times, depending upon the rainfall and the weediness. Regions having protracted rainfall periods require frequent weeding. The plants are earthed up slightly, 4 and 6 months after planting respectively. They tend to grow very tall in fertile areas, when they are cut back, their growth is thus arrested and the development of tubers is promoted. This is not, however, necessary ordinarily and is not common. The crop is irrigated at suitable intervals, except in South Kanara, Malabar, Nilgiris and Visakhapatnam districts, where it is raised purely under rain fed conditions. In other places, an irrigation is given on the day of planting and followed by 2 irrigations, at intervals

of 3 to 5 days, till the sets establish properly. Further irrigations are not necessary ordinarily till the close of the monsoon, as the crop is planted only after the rainy season commences. Irrigations have to be provided later at intervals of 10 to 15 days and 15 to 20 irrigations may be given in all, depending upon the soil and the prevailing rainfall. Light soils require more irrigations than heavy soils in a general way.

Harvest. The development and maturity of tapioca tubers are indicated by the yellowing, drying-up and shedding of the leaves or the plants. In light soils, cracks develop and radiate from the base of the plants, caused by the enlargement of the tubers under the ground. A few plants are dug and examined. Mature tubers shed the earth sticking to them readily and do not snap easily. The occasional appearance of flowers on the plants is not an indication of the maturity of the tubers. An irrigation is given for softening the soil before harvest. The plants can be pulled out from light soils and the tubers separated from them. In loamy soils, the land is dug and the tubers are harvested. About 10 per cent of the stems produced are required for planting the next crop. They are bundled and kept covered with straw in shady places. The rest is dried for fuel. The leaves are used for feeding goats in Malabar.

Yield. The yield of tubers is variable. An average of 12,000 lb. of tubers may be expected from an acre in garden lands, 5 to 6 thousand pounds in east coast districts under rain fed conditions and 8 to 10 thousand pounds in west coast districts, where the rainfall is heavier and more favourable. Under intensive cultivation, the

yield may go up to 15,000 to 20,000 lb. in garden lands and 14,000 to 18,000 lb. in the dry lands of Malabar. Very high yields of 33,000 lb. of tubers are reported to be obtained in Malaya.

Tapioca tubers are 2 to 3 inches across and 9 to 18 inches in length, weighing 2 to 5 lb. each. If the crop is kept on the land for 2 seasons, coarse giant tubers weighing up to 25 lb. each are obtained. The harvested tubers have a short storage life and are fit for use as food for about a week. Later, they get darkened about the central core, due to the concentration of cyanogenetic glucoside and other physiological changes. Their storage life can be increased by keeping them buried in the soil. In view of their low keeping quality, they are harvested in small lots that can be disposed of immediately. The crop can be kept on the land for about 2 months after maturity, but the coarseness and the fibre content of the pulp increase gradually and the tubers get unfit for use eventually.

Processing tapioca. The cultivated varieties of tapioca contain only traces of cyanogenetic glucoside, but still it is not considered that tubers in the raw state are quite safe for consumption. The glucoside is destroyed by cooking and cooked tubers can be used as food. The tubers may be sliced and dried in the sun for use later, when required. The glucoside is destroyed during drying.

Methods of producing starch, tapioca pearls, flour and semolina from tapioca tubers on a commercial scale were developed during the period of the second world war, and small factories in Salem district are engaged in their production.

1. *Starch.* The rind is removed from the tubers with stainless steel knives and sharp bone pieces. Iron knives stain the tubers and the final products are not satisfactorily bright and white. The peeled tubers are rasped and reduced to a pulpy mass. The pulp is mixed with water held in cement cisterns and stirred well. The starch in the pulp gets suspended and makes the water turbid. The turbid liquid is drawn into another tank and the fibrous material of the tubers is thus left behind in the first cistern. The starch in the turbid liquid is allowed to settle and the supernatant liquid is drained. The starch left behind is cleaned by agitating it with a fresh charge of water and allowing it to settle again, when the supernatant liquid is drawn off. The clean starch is then transferred to muslin cloth held up by the corners, when surplus water is drained. Centrifugal machines are also used for the purpose in big factories. The wet starch is spread over cement floor, dried and packed for sale. Caustic soda solution is added to all the cisterns used in the manufacture of starch, to make the liquid slightly alkaline and prevent fermentation setting in.

2. *Tapioca pearls.* At a particular stage of manufacture, tapioca starch has just enough moisture to render it plastic, when it is rubbed through wire sieves and separated into small granules. These are transferred to pieces of cloth kept stretched by holding the four corners, and rocked to and fro, when the granules get rounded and form pellets. They are slightly toasted over hot iron pans smeared with a thin coat of coconut oil and graded according to size. Small sized pellets are called 'sago' and the larger ones 'pearl tapioca', or 'sago pearls'. The use of the term 'sago' and 'sago pearls' for

tapioca products is misleading, since 'sago' is the real name of a similar, but superior product obtained from the central pith of the sago palm (*Arenga wightii*), mainly from the East Indies.

3. Flour. Tapioca tubers are peeled, sliced and dried in the sun. The dry chips are passed through disintegrators and made into flour. The flour is made up of the starch and the crude fibre present in the tubers and it is coarser to the feel than tapioca starch, which is devoid of the crude fibre.

4. Semolina. Tapioca tubers are sliced, cooked in water and dried in the sun. These are ground coarse in flour mills and graded into fractions of different sizes. The coarse fractions resemble wheat semolina and are often used in catering houses in place of the costlier wheat semolina.

The output of starch and tapioca pearls ranges from 12 to 18 per cent on the weight of fresh tubers, depending upon the stage of maturity of the tubers and the efficiency of manufacture. The ratio increases with the maturity of the tubers. The flour output is 25 per cent of the tubers.

Attempts are being made to produce synthetic rice from tapioca flour, which is capable of retaining the original granularity like rice without getting pasty on cooking. A mixture made up of 70 parts of tapioca flour, 20 parts of groundnut cake flour and 10 parts of wheat flour has been made into a vermicelli-like material on a small scale. It is said that it can be mixed with rice up to 20 per cent while cooking, without affecting the palatability, appeal and taste of cooked rice. There is considerable scope for

research connected with the problem of processing tapioca and producing substitutes for the more costly cereals, particularly in India, where there is not adequate and nutritious food, always.

IX. 3 - Sweet Potato [*Ipomoea batatas* (Linn.) Lam.]

Vernacular names: Tamil - cheeni kilanghu or sakkarai valli kilanghu; Malayalam - sakkara kilanghu; Telugu - dumpalu or ghenasu gaddalu; Kannada - ghenasu; Hindi - sakkar kand.

Importance. Sweet potato tubers are agreeable to the palate and the stomach, and meet the carbohydrate requirements of the human system as well as cereals. They are a subsidiary food, which was part of the national diet in parts of America, during the war years. Sweet potato is an important human and livestock food crop in the southern parts of the United States of America. The following statements compare the food values obtainable from the land with sweet potato and rice.

1. Food value of sweet potato tubers and rice.

		Sweet potato tubers	Rice
1.	Duration of the crop in months	5	5
2.	Yield in lb. per acre	7,628	1,127
3.	Protein in lb. per acre	28	78
4.	Carbohydrates in lb. per acre.	2,365	852
5.	Vitamin value per 100 gm. – A	10	—
	B	—	20
	C	24	—

2. Percentage composition of sweet potato tubers and rice. *

	Sweet potato tubers		Rice
	raw	dried	
1. Moisture	66·5	13·0	13·0
2. Protein	1·2	3·1	6·9
3. Fat	0·3	0·8	0·4
4. Carbohydrates	31·0	80·5	79·2
5. Mineral matter	1·0	2·6	0·5

* Source: *Health Bulletin No. 23,* Nutrition Research laboratories, Coonoor, 1951.

Sweet potato produces over 2·5 times as much carbohydrates as rice from the same area. But such comparisons have limited applicability only, because of the wide variations in the soil, climate and water requirements of the two crops. Air-dried sweet potato tubers are as rich in carbohydrates as rice and the other nutrients are present in small quantities only in both the foods. The tubers can, therefore, serve as subsidiary food and can partially replace cereals. Suitable areas can be switched over from cereals to sweet potato, when necessary. This is of particular significance to a populous country like India, where cereal deficiency can be pronounced in years of unfavourable rainfall.

Origin and distribution. Sweet potato is chiefly a crop of the tropics, which is believed to have originated in South America. It is cultivated in the subtropics also. Spaniards are responsible for the spread of sweet potato from South America to the other parts of the world. It does not appear to have been known to early Greeks, Romans, Arabs and Egyptians. Early Chinese books describe a number of varieties and some names bear a close resemblance to the names of certain sweet potato varieties current in America and New Zealand. Whatever

may have been the origin of the crop, it is cultivated widely in many countries today, and millions of people use it as an article of food. Its wide distribution indicates that it is a popular food crop.

Sweet potato is cultivated in large areas in America, and China. India, Brazil, Malaya, East Indies, West Indies, parts of New Zealand and Australia have fair areas. Madras, Andhra, Bengal, Bihar, Bombay and Travancore-Cochin are important regions of its cultivation in the Indian Union.

Its normal extent in Madras and Andhra States is as follows:

MADRAS		ANDHRA	
District	Extent in acres	District	Extent in acres
Chingleput	750	Srikakulam }	3,090
South Arcot	2,800	Visakhapatnam }	
North Arcot	550	East Godavari	200
Salem	840	West Godavari	820
Coimbatore	800	Krishna	30
Tiruchirapalli	4,180	Guntur	290
Tanjore	190	Kurnool	470
Madurai	1,280	Anantapur	310
Ramanathapuram	370	Cuddapah	690
Tirunelveli	2,080	Nellore	240
Malabar	4,520	Chittoor	520
South Kanara	16,090		
Nilgiris	100		
Total (Madras)	34,550	Total (Andhra)	6,660

South Kanara, Malabar, Tiruchirapalli, Srikakulam, Visakhapatnam, South Arcot and Tirunelveli districts have large to fair areas under sweet potato. The other districts have small areas only.

Adaptation. Sweet potato thrives in a hot tropical climate. It comes up in the subtropics also to some extent, during frost-free periods, where it requires a minimum growing period of 4½ months, warm nights abundant sunshine and moderate rainfall. In the tropics, the growing period ranges from 100 to 165 days, depending upon the variety. It exhibits photo and thermo periodisms. Tubers form best in South India during the cool months of the year, when the day light period is short comparatively. Long day light periods are said to promote the formation of tubers and short day light periods the formation of flowers in the U. S. A.

The sweet potato crop requires a liberal supply of moisture and comes up well under rainfed conditions in heavy rainfall regions like South Kanara and Malabar. Where the rainfall is moderate or low, it has to be supplemented with irrigation, as in the other regions in South India. Excessive irrigation and moisture tend to promote vegetative growth at the expense of the tubers. The crop does not tolerate drought, or stagnation of water. The latter is particularly harmful during the time of formation and development of tubers, which tend to get decayed.

The sweet potato crop prefers deep loamy and sandy soils. Its growth is restricted in soils which get hardene on drying and in shallow soils. Clayey soils, soils whic are rich in organic matter and those which are manured heavily with nitrogen promote excessive growth and

retard the formation of tubers. The physical texture of the soil influences the size, shape and texture of the tubers. Heavy soils do not facilitate the proper development of tubers, which are consequently small in size, mis-shapen and hard. On the other hand, the tubers which develop in loose friable soils are good sized, well formed and of a smooth and soft texture.

Season. Rain fed crops are planted in June with the commencement of the south-west monsoon in Visakhapatnam, Malabar and South Kanara districts. The crop is also planted in September at Visakhapatnam, when the north-east monsoon breaks out. It is planted in April-May in the Nilgiris with pre-monsoon showers.

The irrigated crops are planted in September-October almost throughout South India. The planting can be done up to November, but not beyond. These crops get the benefit of the north-east monsoon rains and are irrigated later, when necessary. Further, the nights are cool, the days are not very hot and there is no stagnation of water in the soil during the period of formation of tubers, and these are helpful. The crops planted at other times of the year do not form tubers properly and sweet potato may be said to be season-bound in South India.

The plant and its varieties. Sweet potato is a convolvulus plant with a trailing habit. The stems are thin, pliable and vinous; they are light green when tender and dark green or pigmented purple to brown in varying shades, when mature. The leaf stalks and veins are also of the same colour. The leaves are heart shaped and entire in some varieties, and palmately lobed in different degrees, from light indenting to deep fingering in others. There is free flowering during the cold months of the

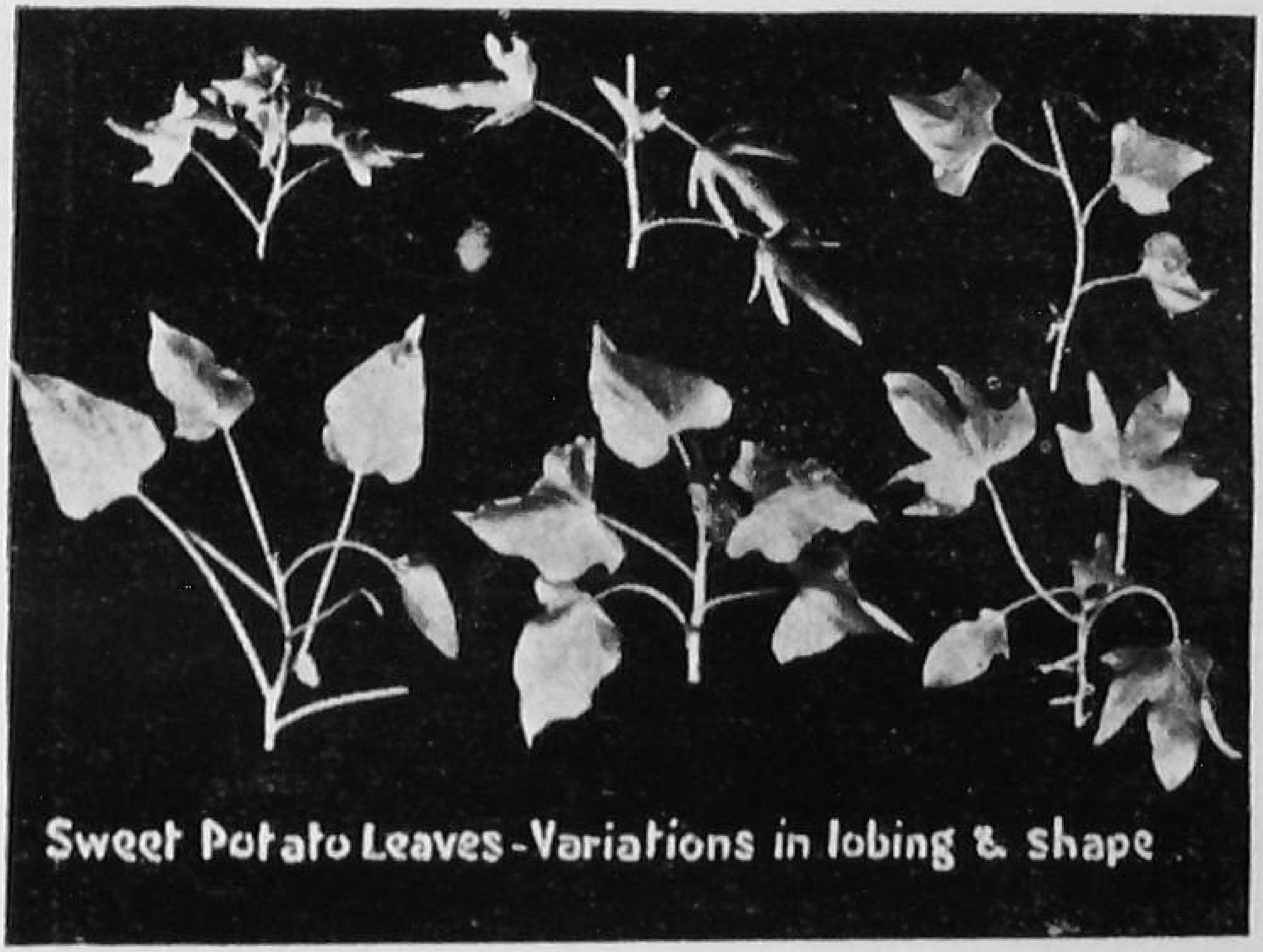

FIG. 34. Sweet potato leaves—variations in lobing and shape.

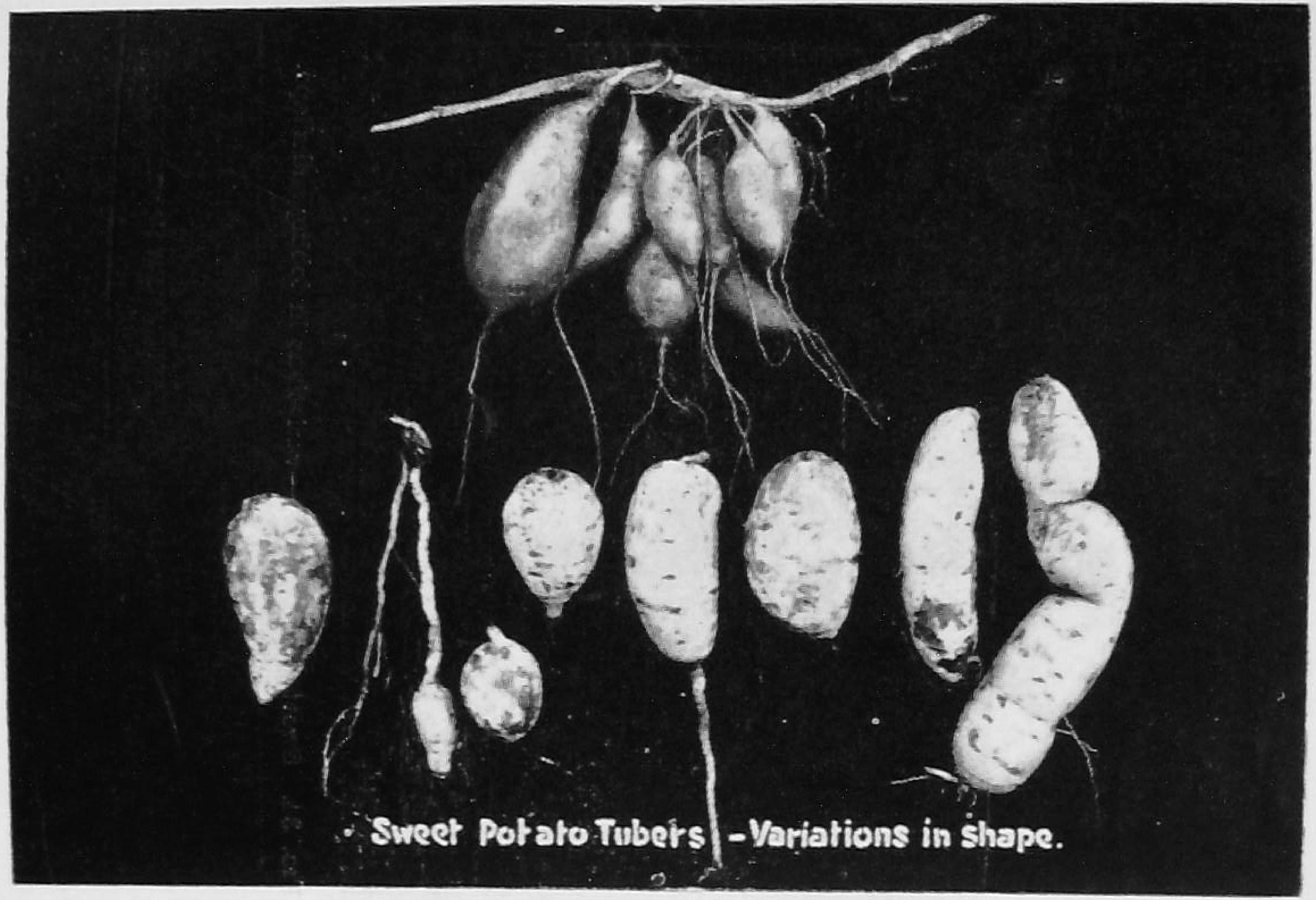

Fig. 35. Sweet potato tubers—variations in shape.

year in South India and it is said to be sparse and uncommon in other countries. The flowers do not set seed normally, due to the incompatibility of the pollen and the ovaries within the same variety, but fertilisation of the ovaries can be effected with pollen from other varieties. Such cross fertilisation has been done successfully and new forms and varieties have been produced. Some of the roots get modified into tubers by the deposition and accumulation of starch. Roots develop from the nodes which lie in contact with the soil and these also get modified into underground tubers. The tubers are variously shaped, rounded, elongated, bulged at the centre or at either end, or conical by the enlargement of the base or the apex. The rind of the tubers is white, cream, yellow or rosy pink in colour. The pulpy flesh inside ranges in colour from white to a deep carrot-like orange. The varieties in South India have white or cream coloured pulp only. The pulp is dry and mealy, or moist and soggy on cooking, depending upon the variety. The dry matter content is commonly more in the former than in the latter.

Sweet potato is propagated vegetatively by planting stem cuttings and tubers, and the number of varieties in existence is, therefore, limited when compared to that of crops propagated by seed. America, East Indies, Hawaii and China have a number of varieties under cultivation. Their names differ from place to place and cause considerable confusion in nomenclature and classification of varieties. Two main varieties, or to be exact two main types alone are recognised by farmers in South India, based on the colour of the tuber rind, that is, the 'Red' and the 'White'. The red type is of a short duration and the yields are generally low. The tubers have an

attractive rosy rind and excellent table qualities. The white type is of a long duration and the yields are heavier. The tubers are of a lower quality. This classification is not very helpful, as many distinct varieties are grouped together and designated as a variety.

The American classification of sweet potato varieties is based on the shape and table quality of the tubers. Types which have globular tubers and those which have a prominent central bulge go by the name of 'Sweet Potato' and the elongated cylindrical types are called 'Yams'. 'Yam' is the common name of the *Dioscoreas* and the corms produced by them, that is in ordinary use in the English speaking countries and to give that name to a type of sweet potato is confusing. When sweet potato tubers are cooked, certain types are granular in texture, opaque in appearance and dry for consumption, producing a feeling of choking when they pass through the gullet. They are called 'dry and mealy types'. Others get cooked to a waxy material, which is translucent in appearance and sweeter to taste; they are called 'moist-fleshed types' or 'moist and sugary types'. The classification is also done on leaf and petiole characters, pigmentation and so forth. No system of classification is entirely satisfactory.

Cultivation. Sweet potato usually follows cereal crops in the common rotations prevailing in South India. The land is ploughed thoroughly, 4 to 6 times, immediately after the harvest of the previous cereal crop and brought to a fine powdery condition. Since the lands devoted to sweet potato are loamy, a good tilth is easily secured. Cattle manure is applied at 15 to 20 cart-loads per acre and incorporated with the soil by the last

ploughing. Cattle are penned in the field during summer in the Circars region, instead of applying cattle manure. If the land is cloddy, the clods are broken by working levelling boards finally. Ridges and furrows, 2 to 2½ feet apart, or beds 9 to 12 feet square with irrigation channels in between are formed. Where water is applied to the land by splashing as in the coastal sandy soils around Bapatla, the beds are 4 feet by 20 feet in size, with bunds all round and no irrigation channels. The lay-out of the land into ridges and furrows, or beds and channels is possibly without effect on the yield of tubers. This is borne out by the results of systematic experiments done in America.

Manuring. Sweet potato is an exhausting crop, which removes large quantities of nitrogen, phosphoric acid and potash from the soil. A 5-ton crop removes the following manurial ingredients from the soil:

Particulars	N lb.	P_2O_5 lb.	K_2O lb.
Tubers, 5 tons	30	10	50
Dry vines, 1 ton	40	11	33
Total	70	21	83
Cattle manure 10 cart-loads	70	36	80

Plant food actually removed by a sweet potato crop depends upon its size. The large quantities of cattle manure applied may normally be expected to supply the plant food ingredients removed by average sweet potato crops. Farmers apply 1 to 2 cwts. of ammonium sulphate per acre to sandy soils, in addition to cattle manure. Fish guano, tobacco stems and wood

ash are applied in Malabar and South Kanara districts before ridging up the sweet potato rows. Green leaves are applied in addition to the above.

Experiments conducted in U. S. A. show that manuring sweet potato with ammonium sulphate or other inorganic fertilizers alone for supplying nitrogen, tends to produce vines at the expense of the tubers. Organic nitrogen is without this drawback. The general advice given is that 1,000 to 1,500 lb. of a 2·5—8—10 complete fertilizer, containing 2·5 per cent nitrogen, 8 per cent phosphoric acid and 10 per cent potash, has to be applied to an acre, with at least 50 per cent of the nitrogen in organic combination. While nitrogen promotes vegetative growth and builds up the plant body, phosphoric acid is required for the development of the roots. Tubers are only modified roots, enlarged by the deposition of sugars and starch. Tuber formation and development are associated with the availability of phosphoric acid. Potash aids the elaboration of starch and is therefore important. When potash is in short supply, the sweet potato leaves get thickened, there is derangement in the mechanism of translocation of starch to the tubers and they do not develop properly. South Indian soils do not ordinarily require potassic manuring, excepting in the West Coast areas, where the application of wood ash supplies the necessary potash. Even in other areas, complete fertilizers may be of some assistance in raising the yield of sweet potato.

Nurseries. The crop is propagated by planting sweet potato vine cuttings produced in nurseries, in two stages. The general harvest of the crop is from January to March and the harvested vines are used for planting

the nurseries, which are called 'primary nurseries' and are one-eightieth of the extent proposed for the next season's planting area. The nurseries are located near wells or irrigation channels to facilitate irrigation during summer months. They are prepared like the main fields. The central portion of the vines is used for planting the primary nursery, discarding the tender tips and the mature basal portions. The vines are cut into sets, 9 to 12 inches long and are planted 9 to 12 inches apart by pressing the central portion into the soil, with the top end sticking out to a greater extent than the basal end. Immature sweet potato tubers left behind in sandy soils at the time of harvest sprout with the moisture in the soil and produce vines. These are also used as sets for planting the primary nursery. The nurseries are irrigated once in 3 or 4 days initially and at wider intervals later. The sets strike roots at the buried nodes and shoots are put out in 7 to 10 days and the vine growths cover the field in 3 months, by about June. These are now cut and planted out in another nursery, called the 'secondary nursery', which is 8 to 10 times the area of the primary nursery. The vines from this second nursery are used for planting the main crop in September.

The planting material can also be produced in other ways. In the U. S. A., a layer of well - trampled fresh horse manure, 8 to 12 inches thick is spread and 3 to 4 inches of sand is laid over it. Sweet potato tubers are placed side by side over the sand and covered with soil. The tubers are thus bedded 6 weeks in advance of planting the main field and the beds are moistened. The fresh dung ferments and keeps the beds warm. Fresh dung can be substituted by decomposed cattle manure.

The tubers sprout and put out numerous shoots. The shoots are pulled out when they are 6 to 9 inches high. They have a few roots developed at the base and are called 'slips'. They are pulled out with one hand, without disturbing the mother tubers, by pressing the soil over them with the other hand. The roots of the slips are dipped in a thick suspension of cow dung and clay. The beds are watered immediately after pulling the slips, to allow the soil to settle down and facilitate the development of further batches of slips. Six to eight bushels (330 to 440 lb.) of tubers bedded in 16 square yards provide 10,000 to 15,000 slips, in 2 or 3 batches, for planting an acre of land. The slips are sometimes allowed to run to vines, which are cut later into sets for planting. The beds are in such cases watered freely with sodium nitrate dissolved in water, at 1 oz. per gallon.

Sweet potato vines are packed in gunny bags, when they have to be transported over long distances. They are succulent, and get heated up and rot during transit. This can be avoided to an extent by wilting the vines and stripping the leaves and tender portions; they keep well for about a week. A bag of fresh vines weighs 60 lb. and it furnishes 5,000 to 6,000 sets.

Planting. Sweet potato vines are planted on the sides of ridges formed 2 to 2½ feet apart or in beds after irrigating them. The spacing given between the sets is 9 to 12 inches in both the methods. The number of sets required for planting an acre ranges from 15,000 to 20,000, depending upon the system of planting and the spacing adopted.

Irrigation. The crop is raised under rain fed conditions in Malabar, South Kanara and Visakhapatnam districts,

and under irrigation in other districts. Irrigations are given at intervals of 3 to 5 days during the period of establishment of the sets and about 3 inches depth of water is applied each time later, as and when necessary. Irrigation is given during the north-east monsoon period., only when rains withhold. After the close of the monsoon, irrigations are given regularly once in 10 to 15 days, depending upon the type of soil and the depth of water applied each time. A light irrigation is given a little before harvest, when the moistened soil facilitates easy harvest. If the moisture is at the correct level, it does not stick to the tubers, which are consequently obtained in a clean condition.

In the coastal sandy soils in the Bapatla region, temporary wells are dug and water is available at a depth of 3 to 6 feet from the surface. Water is lifted in pots and splashed over crops for supplying moisture to the soil. The sweet potato crop is splash watered every day during the first month and on alternate days later. The quantity of water used may be less than that for flow irrigation and the sweet potato crop is given 60 to 70 splash waterings.

The sweet potato requires a steady supply of moisture for the maintenance of its growth, as it has a considerable leaf surface and transpires large quantities of water. The leaves droop when the level of moisture in the soil falls down. If the soil moisture is not then made up, the growth of the crop is arrested and the final yield is depressed. The crop is affected adversely by drought as well as by stagnation of water.

Aftercultivation. Sweet potato gets established within 10 days of planting and starts growing vigorously in

about 25 days, when the land is hoed and the weeds are removed. It is weeded again after a month. Later, the vines strike roots at the nodes, which are in contact with the soil. The vines are lifted periodically and laid down, to disconnect the roots struck at the nodes. This is done under the impression that such rooting promotes the formation of a large number of small sized tubers and that the quantity of marketable tubers produced is consequently reduced. American experiments indicate, however, that such an assumption is not justified; lifting vines is innocuous and does not influence the produce.

Planting sweet potato on ridges is common in the West Coast districts and the ridges tend to get disintegrated by the frequent rains. The ridges are rectified and the rows are earthed-up when the crops are 2½ months old. Green leaves and wood ash are applied in the rows at the time of earthing-up.

Harvest. When sweet potato crops mature, the leaves change colour and turn pale and yellow later in certain varieties, but not in others. As the tubers increase in size, cracks develop about the base of the plants in loamy soils, and it is not clearly evident in garden lands and loose soils. These signs of maturity are not always reliable. A trial harvest of plants selected at random from different parts of the field gives a correct idea of the stage of maturity of the tubers. Mature tubers are brittle, but not the immature ones. The milky juice or latex exuding from the broken ends of mature tubers dries up quickly without any discoloration, while with immature tubers, it takes time to dry up and the dry surface is discoloured and often dark. Mature tubers are not easily bruised, their skin does not

peel readily and soil does not stick to their surface; it is the reverse with immature tubers.

The harvest is commenced a fortnight before the crop is fully mature and continued for about a month. It is done in stages and harvested tubers are disposed of, as they are dug. The harvest of the tubers may be postponed sometimes by a fortnight and the harvested tubers may remain with the farmers for 7 to 10 days at the most, when markets are dull and the demand for tubers is low. Since the tubers are not held in cold storage in this country, the area under sweet potato is limited by the effective and ready demand for fresh tubers. Till a proper method of their storage is developed, the area under the crop will not increase.

The yield and quality are satisfactory only when sweet potato tubers are dug after full maturity. If the crop is kept on the land, after the tubers mature, they are damaged by the sweet potato weevil (*Cylas formicarius*) and the quantity of marketable tubers available gets reduced. The adult weevils and grubs bore the tubers and spoil them. Their burrows get darkened and the surrounding spoilt tissues emit a characteristic unpleasant smell and give a slight bitter taste. Fungal and bacterial damage follow in the wake of the weevil attack. The affected tubers get unfit for consumption. The extent of damage is considerable and has to be seen to be believed; 40 per cent of the tubers get damaged in a fortnight and 70 to 80 per cent in the course of a month. Immature tubers are seldom affected severely. Why the weevils attack the mature tubers and leave the immature ones unaffected is not quite clear. It appears not improbable that it may be due to the difference between

the attractabilities of the two caused by the change in the quality of the latex. The latex loses its milkiness and viscosity, and becomes limpid as the tubers mature. The weevil is a serious pest in certain localities and maintaining the planting material in the field right through the year is one of the main causative factors. The ready availability of alternate host plants is another. Taking all these into consideration, the harvest may advantageously be taken up immediately after marketable tubers are formed, though the yield may be lowered by the earlier harvests. Where, however, weevil damage is low and negligible, the harvest may be done at the correct stage of maturity or even later, if necessary.

The harvest commences with the cutting of the vines and clearing the ground. The field is dug with crowbars and spades, and the tubers are collected and cleaned of the adhering earth. Of the tubers obtained, 70 to 80 per cent are marketable and the others are small sized, immature, diseased or damaged while digging. The cut tubers are sold for nominal prices and are purchased by poor people for immediate consumption. The immature and small tubers are used for feeding cattle and the diseased ones are discarded. The tubers are sent to the market in bulk, or packed in gunny bags.

Sweet potato can also be harvested with potato digger ploughs. These have skim coulter attachments, which cut the vines in advance and clear the ground. The mouldboard of the plough has slots, through which the furrow slice slides back to its own furrow and the tubers are delivered in rows close to the furrow. The tubers lie partly buried in the loosened soil ready for gathering.

Marketing. Sweet potato acreage is regulated by the demand from the consuming centres. It is perishable and is not moved over long distances. Urban areas are the main consuming centres and are catered to by the producing areas round about. Madras city is a big consuming centre and collects the produce from the neighbouring districts of Nellore, Chingleput, South Arcot and North Arcot. Similarly, the various district and taluk head quarter towns draw their requirements from the surrounding taluks and villages respectively, through vegetable vendors and middlemen. The several weekly shandies serve as collecting centres, where the peasants dispose of their crop directly. The harvests are adjusted to the current demand in the consuming markets. The tubers left unsold in the principal markets are hawked in villages.

Storage. Sweet potato tubers are not held in storage in India, whereas it is a normal feature in America. The storage houses are insulated structures, where temperature and aeration are regulated and maintained at the desired level. The tubers are kept spread out on racks arranged in tiers one over another in the storage houses and the temperature inside is maintained at 115° to 130° F. for 7 to 20 days. They lose some moisture during the period; 6 per cent of the moisture may be lost in the first week and another 6 per cent in the next fortnight. The temperature is then reduced and maintained at 55° to 65° F., till the tubers are marketed. The tubers keep well in storage as, (1) mature tubers, free of disease, bruises and other blemishes alone are kept in storage, (2) their moisture content is reduced to a safe level by sweating at high temperature initially for varying periods, depend-

ing upon the original moisture content, and (3) the storage temperature is maintained at the appropriate level.

Changes take place in the tubers during storage, after the preliminary sweating and curing. There is a further slight loss of moisture. A part of the starch, up to 25 per cent, is converted to dextrose to start with and to sucrose finally. There is a small rise in the dextrose content and a larger rise in the sucrose content of the tubers.

Surplus tubers which cannot be accommodated in the existing storage houses are kept in conical heaps, called 'clamps', with a ventilating shaft in the centre projecting beyond the top for providing aeration for the tubers. The tubers are piled over thick bedding of straw, and covered with straw and finally with a thick layer of soil to serve as insulating material. When tubers are required for the market, they are removed from the clamps and storage houses, cleaned, graded according to size and shape, and packed in baskets and barrels.

A simple method of holding sweet potato tubers in storage is followed in Africa. The fresh tubers are spread out in shade for a few days, when there is some loss of moisture. These are packed in pits in layers alternately with wood ash and the pits are covered with a layer of soil finally. The tubers are said to keep well without spoilage. Even when some tubers are spoilt, the spoilage does not extend to the adjacent tubers, as the ash acts as a buffering medium. Any powdery material like sand or road dust is as efficient as ash and can be used for sandwiching between the tubers.

Sweet potato tubers are conserved by drying in West Africa. Fresh tubers are spread out and wilted for

2 or 3 days. They are washed and cooked in water for an hour. The cooked tubers are split into 3 or 4 sections longitudinally and dried in the sun, till they are brick-hard. The dry slices keep well for over 2 years at the room temperature, when stored in closed mud pots. The dry slices are washed in water and cooked like fresh tubers, when required. The preserved material is tastier than even fresh tubers.

When sweet potato tubers are cooked, there is conversion of part of the starch to sugars. The sucrose content rises slightly and the dextrose content rises by 4 to 9 per cent. The starch in the tubers is subject to the action of diastatic enzymes present in the raw tubers, when the temperature is raised from 60° to 100° C., and maintained for 1 to 1½ hours. This may account for the improvement in the taste of the tubers desiccated by the West African method.

Uses. Sweet potato tubers are used in South India as vegetable and as a light repast after boiling them in water with a little salt. Cooking the tubers in steam with the jacket on, gives a tastier product. Baking with red hot embers develops the full flavour of the tubers and gives the tastiest product. Sweet potato flour, made from sun dried slices, can be made into porridge and taken with milk and sugar. The flour can be mixed with wheat flour up to one eighths, for making *chappathis* (thin unleavened bread), bread and biscuits. The tubers are canned and dehydrated in other countries and the processed products keep well for long periods in ordinary storage. Starch, syrup and alcohol are made from the tubers on a commercial scale in America. The cultivation of sweet potato has consequently expanded and it has become an important commercial crop there.

Low grade tubers and sweet potato vines are used as feed for livestock. The green vines are made into silage in a small way in America which, however, is slimy and inconvenient for handling. They are also dried and hay of medium to good quality is produced. Cattle are fed with green vines in South India and what is not immediately consumed is put in the manure pit and wasted. They are a good feed for milch cattle and are comparable to succulent leguminous fodder in value, but they are apt to loosen the bowels when used as the sole roughage. They may be used safely at 30 to 40 lb. per animal daily and supplemented with dry fodder. Surplus vines can be dried and used as hay. The hay contains about 17 per cent of protein and is a protein-rich roughage.

The following analyses furnish the percentage composition of the various types of sweet potato produce:

Produce	Green vines	Air-dry vines	Silage	Raw tubers (range of)	Desiccated tubers
Dry matter	13·58	90·00	45·13	21·74-41·15	89·54
Moisture	86·42	10·00	54·87	78·26-58·85	10·46
Ash	2·98	19·75	1·85	0·76—1·58	3·04
Crude protein	2·58	17·11	1·82	1·02—2·91	4·50
Fat	0·32	2·12	0·66	0·55—1·66	1·18
Crude fibre	3·05	20·22	1·48	1·11—1·69	1·91
Carbohydrates *	4·65	30·80	39·41	15·38-34·42	78·91
	* inclusive of				
	1. invert sugars			2·08—5·74	18·55
	2. sucrose			0·58—7·23	10·93
	3. total sugars			2·77-11·90	29·48
	4. starch			12·61-22·52	46·22

Sweet potato tuber is mainly a carbohydrate food and its food value is, therefore, dependent on its carbohydrate content. The dry matter content of raw tubers ranges from 15·38 to 34·42 per cent with the minimum and the maximum being in the ratio of 1 : 2·24. If a variety '**A**' having a carbohydrate content of 15·38 per cent yields 10 tons of raw tubers per acre, the carbohydrate production from an acre will amount to 1·538 tons. The same quantity of carbohydrates will be furnished by 4·4 tons of raw tubers of another variety '**B**', which has a carbohydrate content of 34·42 per cent. An yield of 10 tons of raw tubers per acre of the variety '**A**' is equivalent to an yield of 4·4 tons of '**B**'. If the yield of '**B**' is over 4·4 tons, it will be superior to '**A**'. It is, therefore, clear that comparisons of the value of varieties by their raw tuber yield alone cannot be correct. Though the carbohydrate yield will give a correct idea, its determination requires laboratory facilities. If the raw tubers are sliced, dried and the air-dry matter yield is obtained, it will furnish some basis for comparison of the relative values of the different varieties. Air-dry matter, dry matter and carbohydrate content are roughly inter-related and carbohydrate yields follow air-dry matter yields. A comparison of air-dry matter yields is good enough for practical purposes, while evaluating different varieties.

Yields. The yield of sweet potato tubers appears to be associated with the vigour of the vines, but not necessarily with their growth. Though a certain amount of vine growth is required for the production of tubers, an excessive vine growth is generally at the expense of the tubers.

The yield of sweet potato is very variable. Rainfed crops give on the average 5,000 to 7,000 lb. of tubers per

acre and 6,000 to 10,000 lb. of green vines. Irrigated crops yield 8,000 to 15,000 lb. of tubers and 12,000 to 25,000 lb. of vines in general. Much higher yields are obtained by farmers, with skill and careful cultivation. The average yield in South India may be estimated to be 8,000 lb. of tubers and 13,000 lb. of green vines per acre.

Sweet potato, planted in December - January as a green fodder crop, gives 3 or 4 cuttings from March to May, aggregating to 55,000 to 70,000 lb. of green vines per acre. The growth of vines is vigorous in summer, when compared with that of fodder crops like sorghum and maize.

IX. 4. Potato (*Solanum tuberosum* Linn.)

Vernacular names: Tamil and Malayalam - urulai kilanghu; Telugu - urula gadda; Kannada - urula gadde; Hindi - alu.

Importance. Potato is an important item of food, in daily use, in temperate countries. The annual consumption of potato in pounds per head of human population is 400 in France and Germany, 210 in the United Kingdom, 205 in Canada, 155 in U. S. A. and 10 in India. While potato is the common man's food in other countries, it is an article of luxury in India, consequent on its low production and high cost. It is used as vegetable in India, in common with other roots and tubers. It can be kept in storage for many months and does not deteriorate or perish easily. It has no distinct flavour or taste by itself, but it lends itself for being cooked in various ways, by baking, boiling or frying and blends well with all articles of food, of both vegetable and animal origin. It can be dehydrated and kept in store, for emergent use, when required. It is mainly a carbohydrate food

and has about the same carbohydrate content as cereals, on a dry basis. It has a dry matter content of about 25 per cent, while cereals have 87 per cent, and $3\frac{1}{2}$ parts of potato supplies the same amount of energy to the human system as one part of cereals, by weight.

Origin and distribution. Potato belongs to the genus *Solanum*, which contains over 2,000 species of plants. About 150 of these bear tubers and many tuberous species grow wild in nature in the highlands of Central and South America. Chile in South America is the original home of the potato. It is believed to have been introduced into Europe during the 15th century and into India during the 17th century, It was introduced in the Nilgiri Hills in 1822 by Sullivan, the then Collector of Coimbatore. The locality was congenial to potato and its cultivation increased gradually. It is the most important food and commercial crop in the Nilgiris, now.

Potato is an important food crop in several parts of the world and the extent of its cultivation and production during 1952 were as follows:

Name of country	Extent in 1,000 acres	Production of tubers in 1,000 tons *
Canada	294	1,474
United States	1.398	8,688
France	2,590	10,945
Germany	2,834	21,912
United Kingdom	990	7.325
U. S. S. R.	23,400	72,500
India	600	1,500
South America	1,902	3,935
Africa	286	674
Australia	125	375
Others	18,547	80,828
World Total	529,66	210,156

Source: *U. S. D. A. Agrl. Statistics*, 1953 - '54. * Bushels converted to long tons, taking that 40 bushels are equal to a ton.

Potato is cultivated in 6 lakhs acres in the Indian Union, of which 90 per cent or 5·4 lakhs acres are under 'winter' crop in the plains of North, West and Central India. It is being cultivated intensively in Simla, Assam and the Nilgiri Hills, in 0·6 lakhs acres.

The most important potato area in South India is in the Nilgiri Hills, where the crop occupied 4,000 acres in the year 1914, 8,000 acres in 1920, 12,000 acres in 1938 and about 25,000 acres in 1954. The large demand from the occupational forces during the second world war, the high prices ruling, and the increase in demand for seed from other States and for consumption from all over the country, gave the necessary fillip to the increase of the extent under potato cultivation. The other areas of potato cultivation are the Kodaikanal Hills in Madurai district, and the Shevroy Hills and the Hosur taluk in Salem district, with about 900 and 500 acres respectively.

Adaptation. Potato is primarily a crop of the temperate regions, where the climate is of a mild type. Potato tubers do not develop properly, when the daily maximum temperature exceeds 85° F. The crop is able to tolerate lower temperatures, but not frost. Side by side, it requires bright sunshine also, for the elaboration of carbohydrates, which are translocated and stored as starch in the underground tubers. Potato cannot, therefore, be cultivated successfully in the tropical plains, except where the maximum temperature does not rise above 85° F., during the cooler months of the year. The cultivation of potato on the plains in Madras and Andhra has not been successful. As the maximum temperature is above the limits tolerated by it in the plains, even during the winter months, potato tubers do not develop properly and their

yield also is low. It is cultivated in the hill slopes in South India, where the temperature conditions are suitable for the crop at an altitude of 7,500 feet in the Nilgiris, and of 4,500 to 6,000 feet in the Shevroys and the Kodaikanal Hills. It is cultivated mostly on the plains in subtropical and temperature regions. It is, therefore, the temperature and not the altitude that decides the success of potato cultivation.

Potato requires considerable moisture for its growth, steadily right through the growing period, and it does not tolerate stagnation of water in the soil. It is a 4 month's crop in South India and requires frequent and timely rains for at least 3 months from the time of planting. When the rainfall is inadequate, it has to be supplemented with irrigation. The summer crop on the Nilgiris is raised only under irrigation; the crops grown in other seasons are raised under rain fed conditions, and the rainfall during the growing period ranges from 20 to 25 inches.

Potato thrives in well drained loamy soils, which are fertile and rich in organic matter content. The pH of the soil that is most suitable is 4·5 to 6·0. The soils on the Nilgiris are from these points quite suitable for potato. Alkaline soils are definitely unsuitable for the crop.

Seasons. Potato is cultivated in the following seasons on the Nilgiris:

No.	Name of crop.	Month of planting	Month of harvest	Approximate extent in acres
1.	Irrigated crop	February	June	2,000
2.	Second crop	September	January	8,000
3.	Main crop	April	August	15,000

The irrigated crop, sometimes called the 'summer crop' is confined to the valley regions, which are irrigated by jungle streams. The other two crops are raised under rainfed conditions. The irrigated crop harvested in June supplies seed tubers for planting the second crop in September. Similarly, the second crop supplies seed for the main crop and the main crop for the irrigated crop. Thus all the 3 crops are dependent on the crop harvested just previously, for the supply of seed tubers.

Varieties. There are a large number of commercial varieties of potato in the different parts of the world. The variety which has established itself and which is grown almost all over the Nilgiris is the 'great Scot', an English variety. It is the grower's choice and has many strong points. (1) It is of medium duration, (2) it lends itself for being grown in all the 3 seasons, enabling supply of seed tubers from one crop to another, (3) it has a good round shape, an attractive skin and medium set eyes, points which appeal to the consumer, (4) the tubers keep well and stand transport over long distances, (5) it is firm and retains the shape after cooking, without becoming mushy or melting in the boiling liquid medium and (6) it is tolerant to many viruses. Certain varieties like the 'President' and 'Up-to-date' are known to be heavy yielders, but they are apt to suffer severely, when the rains are confined to a short period alone during the monsoon season in certain years, on account of their long duration.

Rotations. Potato is an exhausting crop and is not grown on the same field every year, though it can be done, without detriment to yield, if a green manure crop like lupin is raised in between potatoes as an off season

crop and ploughed into the soil. It is commonly grown in rotation with *ragi* or *samai* in alternate years in a 2 year rotation. Sometimes, the land is left fallow in the third year after the cereal, and potato is then cropped once in three years.

Cultivation. The land is brought to good tilth by ploughing 4 or 5 times, or by digging with *guddaly*, the local tool which resembles a pick axe. Cattle manure is applied at 10 cart-loads to an acre, before the last ploughing. The land is then laid into ridges and furrows, spaced 2 feet apart. The depth of the furrows is limited to 7 to 9 inches.

Seed material. Fresh tubers are dormant and do not germinate immediately after harvest. Sound tubers, 1 to 2 ounces in weight, are selected for planting and kept on wooden racks, arranged in tiers one over another, in rooms with good ventilation, but without any direct sunlight. The tubers are arranged 3 or 4 layers deep. There is adequate aeration and the loss caused by rotting is negligible. Sprouts begin to appear on the tubers, 6 to 8 weeks after storage and the best stage for planting is just when the sprouts emerge from the eyes or the small depressions on the surface of the tubers. The dormancy of fresh tubers can be broken and they can be induced to sprout, or force-sprouted by fumigating them with carbon disulphide for about 10 days. The fumigated tubers are kept in dark rooms for 3 weeks, when they germinate and get ready for planting.

Sound tubers, which are 1½ to 2 oz. in weight, give optimum yields under the conditions prevailing in the Nilgiris. Small tubers tend to give low yields. When large sized tubers have to be used for planting, they are

cut into pieces, called 'sets', which weigh about 2 oz. each. Potato sets are not preferred for planting, when suitable whole tubers are available. The crops raised from entire tubers are able to withstand spells of dry weather in the early stages, while those raised from sets come up normally, only when the moisture in the soil is satisfactory. Tubers weighing about 2 oz. each have sufficient food reserve material to give the plants a good start, at the time of establishment. Smaller tubers do not have this advantage. Larger tubers are not specially advantageous, as plants depend upon the soil and not on the tubers for supply of nutrients after establishment. The use of large seed tubers weighing over 2 oz. is not, therefore, economic.

Planting and manuring. The seed tubers are placed in the furrows 8 to 9 inches apart and 10 bags (about 2,000 lb.) of tubers are required for planting an acre. A balanced manure mixture is then applied in the furrows. The Nilgiri soils are rather poor. They are acidic in reaction and consequently, they have soluble iron and aluminium, which tie-up phosphates and make them unavailable for crops. As a result of experiments conducted with the object of determining the quantities and form of the several manurial ingredients required for producing satisfactory response in potato, the complete 4·25—10·7—5·5 manure, called the 'Nanjanad potato mixture' was evolved. It is applied at 1,946 lb. (= 10 bags) to an acre and its composition is given in the next page.

The manure mixture is applied in the furrows, on a level with the seed tubers and both the seed tubers and the manure are covered by splitting the ridges between the furrows.

Composition of the 'Nanjanad potato mixture' used for an acre.

Ingredients used	Quantity	containing		
		N	P_2O_5	K_2O
	lb.	lb.	lb.	lb.
Groundnut cake meal	500	35		
Ammonium sulphate	200	40		
Bone meal	350	10	80	
Superphosphate	672		134	
Potassium sulphate	224			108
Total	1,946	85	214	108

Aftercultivation. Potato shoots emerge out of the soil in about 3 weeks and the emergence is complete in 5 weeks. The crop is then weeded and slightly earthed-up. It makes vigorous growth and covers the ground in another 5 weeks, that is, in 2½ months after planting. It is weeded and earthed-up finally. This has to be done rather carefully, without disturbing the underground stolons, which develop and begin to form tubers 50 days after planting. The soil round the plants is also loosened at the time.

The summer crop is given 10 to 12 irrigations, depending upon the rains received and the moisture present in the soil.

The crop shows signs of maturity in about 3 months after planting. The leaves turn yellow and are shed in course of time and the haulms dry up and die, which may be taken to be an indication of maturity. The duration of the crop varies with the variety and that of 'Great Scot' is 4 months in the main crop and the irrigated summer crop seasons, and one week less in the second

crop season. The crop is lifted carefully, without injuring the tubers. If the tubers are lifted before they are fully mature, the soil tends to stick to their surface, their skin peels off readily and the injured surfaces get discoloured, which leads to a fall in the market value and keeping quality. The immature tubers are also not tasty.

After the crop is lifted, the mature tubers are left on the field for a while, for the skin to get dry and shed the soil sticking to the surface. The tubers are then graded into (1) 'Table' or 'Ware' potato, over 2 oz. each in weight, (2) seed tubers, 1 to 2 oz. each and (3) 'Chats', which weigh less than one ounce. Diseased, cut and immature tubers are removed during grading. The different grades are packed separately in gunny bags and sent to Mettupalayam, which is the despatch railhead for the Nilgiri potato.

Yield. The normal yield of potato on the Nilgiris is 10,000 to 12,000 lb. per acre for the main and irrigated crops, which is 5 to 6-fold the seed used for planting, on the assumption that 2,000 lb. of seed tubers are planted in an acre. The second crop gives 8,000 to 10,000 lb. of tubers per acre.

IX. 5—Elephant foot yam (*Amorphophallus campanulatus* Blume.)

Vernacular names. Tamil-senai kilanghu; Malayalam-chena; Telugu - theeya kanda; Kannada - dodda swarna gadde; Hindi - zamin kand.

Adaptation. Elephant foot yam is cultivated in small areas by individual farmers in Malabar, Coimbatore, South Arcot, Chittoor, Ramanathapuram and Godavari districts in rich, deep, loamy soils, where facilities exist

for copious irrigation or where the rainfall is abundant and distributed over a long period. It is not able to stand stagnation of water and is cultivated in highlands only, in heavy rainfall regions like Malabar. Where the rainfall is moderate or low as in other regions, irrigation has to be provided.

Cultivation. It is cultivated in Malabar as a pure crop and is sometimes grown mixed with ginger. No special rotation is followed. It follows turmeric at Coimbatore and sugarcane at Godavari, which are heavily manured and leave the land with considerable residual manure value. It is an exhausting crop and is not cultivated in the same field oftener than once in 4 or 5 years.

The land is ploughed deep, repeatedly up to 10 or 12 times even, and cattle manure is applied at 30 to 40 cart-loads to an acre before the last ploughing. Decayed rice and *varagu* straw are sometimes applied and incorporated with the soil. At Chittoor, sheep are penned at 2,000 sheep-nights to an acre, in addition to cattle manuring. Ridges and furrows are opened 2 to 2½ feet apart and irrigation channels are provided across the ridges at distances of 10 to 15 feet. The crop is planted usually in April—May, though it can be planted up to July at the latest. The crops planted at other seasons do not come up satisfactorily. Corms, or the modified stem tubers formed at the base of the plant obtained from the previous crop are preserved and used as the propagating material. The central protuberance at the top shows the scar formed, where the stem was severed at the time of the harvest. There is a depressed ring round the stem scar, 3 to 5 inches in diameter, depending upon the size of the corm. A few small tuberous projections or tubercles

are seen in the ring and these are the rudimentary buds in different stages of development. The corms are cut longitudinally into a number of seed pieces, each having a small area of the ring region, with one small tubercle at least. Large corms are cut into 7 or 8 pieces and small ones into 3 or 4 pieces and each piece may weigh 2 to 5 ounces, depending upon the size of the corm. These are planted near the base of the ridges, 1½ feet apart and the land is irrigated. The spacing is based on the spread of the plants in the locality. The quantity of corms required for planting an acre is 800 to 1,500 lb., depending upon the size of the seed corms; a heavy seed rate results when large corms are used for seed purposes. Germination commences in about 10 days and may continue for 6 weeks depending upon the development of the rudimentary buds. Those that are well developed sprout immediately and the small dormant buds take a long time to sprout.

The crop is weeded frequently and 6 weedings may be required ordinarily. Irrigations are given once a week, when there are no rains. The primary shoots develop to 3 to 4 feet and secondary shoots spring up from the base, 4 months after planting, when corms form and commence development. The corms are dug from December onwards, when the crop is 7 months old and continued up to the following March, depending upon the market conditions. The leaves turn yellow in 8 months, when the corms are fully developed and mature. The corms vary in size and may range from 1 to 8 lb. each. Those produced in Malabar weigh 4 to 6 lb. each on the average and 1 to 1½ lb. each in Chittoor and South Arcot.

Sound and mature corms are selected for propagation and kept heaped in shade, covered with rice straw. The heaps are sometimes covered finally with a plaster of cow dung and earth, in hot places.

The crop is kept on the land for 2 years continuously sometimes in Malabar. The corms are planted 3 to 4 feet apart both ways, for these two year crops. The shoots dry up in summer at the end of the first season and the corms developed under the ground sprout in May-June with the commencement of the south-west monsoon. The corms are dug at the end of the second season and they are big in size and weigh 8 to 10 lb. on the average. Heavy corms weigh up to 16 to 18 lb. each and are 8 to 10 inches across and 5 to 7 inches in height.

The yield of corms ranges from 12,000 to 15,000 lb. per acre, with a 8 to 12-fold increase after one season's growth and 25,000 to 30,000 lb. after two season's growth.

IX. 6 - Colocasia (*Colocasia antiquorum* Schott.)

Vernacular names: Tamil - sheppan kilanghu; Malayalam - chembu kilanghu; Telugu - chama gadda; Kannada - kesu gadde; Hindi - alvi.

Colocasia is a stem tuber that develops underground at the base of the plants. It has a sliminess, like *bhendi* (*Hibiscus esculentus*) and is fine textured and tasty. It is possibly the easiest to digest among the tuberous vegetables and is a favourite with consumers. It can be cultivated in low lying moist situations and certain varieties are planted by the side of irrigation channels and the base of the plant is perpetually laved with water.

The land is prepared by ploughing 3 or 4 times, Pits. 1 foot square and 9 inches deep are dug, $1\frac{1}{2}$ feet apart each way and they are left for weathering. The pits are filled in March-April and 2 or 3 colocasia rhizomes are planted in each pit, after applying 3 to 4 lb. of cattle manure; 15 to 20 cart-loads of cattle manure and 600 to 800 lb. of rhizomes are required for planting an acre. The crop is weeded thrice and irrigated at intervals of 4 or 5 days. The crop is harvested in October, 6 to 7 months after planting. The yield of rhizomes is 7,000 to 10,000 lb. per acre or a 12 to 16-fold increase of planting material.

IX. 7 - Yams (*Dioscorea esculenta* Burk. and *D. alata* Linn.)

Vernacular names: Tamil - valli kilanghu; Telugu - pandalam.

Yam is a vegetable that is cultivated for its edible stem tubers. It is a vinous plant with a climbing habit. The leaves resemble betel vine leaves. It is grown here and there along with betel vines in Tamil Nad. It thrives under moist soil conditions and is cultivated in a field scale in the West Coast districts and the Circars coastal districts, where either the rainfall is heavy or the supply of water for irrigation is available in abundance. It is cultivated like the elephant foot yam, otherwise. The distance given between plants is 2 feet each way and the vines climb on bamboos planted by their side.

D. alata Linn. forms big sized tubers, weighing 5 to 15 lb. each, which are coarse in texture. The tubers are also slimy. The tubers are cut into a number of small pieces, each having one well developed shoot, and

200 to 300 lb. of tubers are required for planting an acre. The crop gives heavy yields of 15 to 18,000 lb. of tubers per acre.

D. esculenta Burk. is not so robust and the tubers are small, ½ to 1 lb. each, rounded, or slightly elongated, and fine grained, with a distinct flavour and taste. The flesh is yellow in colour. The tubers are considered to be superior to even potato, by some. This species produces aerial tubers also, borne like fruits on the vines. These have an off taste and are used as propagating material. The underground tubers also can be used for planting. Small tubers are planted entire and the big tubers are cut into 2 or 3 pieces, with at least one well developed shoot in each piece. The quantity of seed material used for planting ranges from 150 to 200 lb. per acre and the yield of tubers ranges from 5,000 to 7,000 lb. per acre.

CHAPTER X

SUGARS

Sugarcane (*Saccharum* species)

Vernacular names: Tamil - karumbu; Malayalam - karimbu; Telugu - cherukku; Kannada - kabbu; Hindi - ganna.

Importance. Sugarcane is one of the important commercial crops in the tropics. It was the chief source of sugar, until the time of Napoleon, who encouraged the cultivation of the sugar beet (*Beta vulgaris*) in Europe. The beet sugar industry got firmly established in course of time and it became the counterpart of sugarcane in the temperate regions. Sugar production is now shared by cane and beet sugars in the ratio of 2 : 1 roughly. Sugar is also produced in small quantities from sweet sorghum, maple and various palms, like the palmyra, date, coconut and sago.

Origin. Sugarcane has been under cultivation from very early times in India, which is considered to be the original home of sugarcane. The thin hardy types of sugarcane which were under cultivation originally in India constitute the species '*barberi*' of the genus '*Saccharum*'. It was taken from India to Egypt during the 7th century A.D. and from Egypt to Spain and thence to West Indies, Brazil, Mauritius and other places later. Thick juicy types of sugarcane, called the 'noble' canes and classified as *S. officinarum* Linn. were introduced into India during the 19th century. They are not so hardy

as the thin canes, but are capable of making vigorous growth and giving high yields under favourable conditions of soil, climate and cultivation. The home of the thick canes is considered to be the Polynesian Islands in the Pacific Ocean. The origin of some of the present local South Indian sugarcane can be traced to the early introductions from Mauritius. The 'Vellai' and 'Poovan' canes, and the red, purple and striped 'Mauritius' canes which are under cultivation in South India are only 'Mauritius' canes. Introductions were made from several countries at different times. P.O.J. 2878, or the 'Wonder cane of Java', B. 208 from Barbados and Fiji B are some notable exotic canes which adapted themselves to the conditions prevailing and got a footing in South India. All these varieties ousted practically the local indigenous thin sugarcanes, which are grown now in small areas only in isolated pockets, here and there.

Historical resume. New varieties of sugarcane were introduced into India in the earlier years either for increasing the yield or for substituting the local varieties, which were susceptible to diseases. The resuscitation of sugarcane cultivation in Godavari region by the introduction of red and purple 'Mauritius' canes is of recent date. Red rot disease was widely prevalent among the local canes towards the close of the 19th century and sugarcane was in imminent danger of going out of cultivation in the area. An agricultural research station was opened at Samalkota in 1902, with the object of resuscitating sugarcane cultivation. A number of varieties of sugarcane were introduced from other countries for trial. Among them, red and purple 'Mauritius' canes were resistant to red rot, and they spread rapidly and saved the situation.

The production of fertile sugarcane seeds in Java in 1888 marks an era in sugarcane development work. The production of sugarcane seeds and seedlings revolutionised sugarcane improvement work. Sugarcane was being propagated previously by planting stem cuttings alone and the production of better types consisted of locating new 'sport' forms, superior to the parent material. Spontaneous variations appeared in sugarcane once in a way and new forms which appeared were generally poorer than the parent material, and superior forms appeared only rarely. India started producing sugarcane seedlings nearly two decades later. The sugarcane breeding station was opened at Coimbatore in 1912, where sugarcane was then noted to produce flowers and not at other places. By crossing selected types of sugarcane, superior thin canes suitable for cultivation under rain-fed conditions in North India were produced. *S. Spontaneum*, a wild species allied to the cultivated sugarcane was deliberately crossed with the cultivated types, for inducing hardiness and capacity to withstand adverse soil and climatic conditions, in the hybrids. The new thin canes, called the 'Coimbatore canes', or the 'Co. canes' gave higher yields than the old local canes of North India, in some cases by over 60 to 70 per cent. They became popular, displaced the local canes and became the standard canes in North India.

The improvement of thick canes was taken up later during the twenties and improved strains were produced. They have practically displaced the varieties, which were under cultivation in South India previously. The thin and the thick canes of Coimbatore have been taken to other countries, and some have adapted themselves to their new environment both under subtropical and tropi-

cal conditions. They are valued as suitable materials for hybridisation.

The Indian sugar industry. India was producing and exporting sugar originally during the early days of the East India Company and Great Britain was the chief market. Later, however, sugar was produced in other British colonies, for which England showed preference and subjected Indian sugar to heavy import duty. This closed the British market for the Indian sugar and the sugar industry in India languished. Beet was then establishing the sugar industry in Europe and an outlet for colonial sugar was sought in India. She was exporting sugar up to 1878 and started importing sugar during the year. She became in course of time a steady market for colonial sugar, particularly the Javanese sugar. It took a little over 50 years for this to change.

The sugar industry in India received a fillip in 1929, as a result of certain legislative measures undertaken by the Government of India. On the recommendation of the Sugar Committee of the Imperial Council of Agricultural Research, New Delhi, a tariff board was set up for enquiring into the condition of the Indian sugar industry and for suggesting methods of its rehabilitation and stabilisation. It recommended the levy of a duty on imported sugar for a period of 15 years, as a measure of protection for the indigenous sugar industry. It was accepted by Government and implemented in a slightly modified form. The Sugar Industry (protection) Act of 1932 came into being and a protective duty was imposed on imported sugar for a period of 6 years, up to 1938. The protection was extended later, in stages up to 1950. It was extremely effective in stimulating and developing

the sugar industry. The number of sugar factories in India was 32 only during 1932. It increased to 112 within 2 years and rose to 150 by 1940. The production of sugar in India was one lakh tons in 1932 and 11 lakhs tons in 1936, which was in excess of the demand in the country by about 50,000 tons. Side by side with the increase in production, there was a fall in the import of sugar into India from 1932 onwards, and imports almost ceased in 1936. The industry expanded considerably during this period and became the second largest industry in the country, ranking in importance next to cotton only.

Since the protection afforded originally has now been removed, the sugar industry has to be self supporting and has to be managed efficiently in the several stages of production. The production of sugarcane economically assumes considerable importance, as the cost of raw sugarcane is a big sizable item in the total cost of production of sugar. There is great scope for expanding the extent and intensity of cultivation of sugarcane in the irrigated zones in Madras, Andhra, Mysore and Bombay States, which have a favourable tropical climate.

World production. The estimated production of sugar during the year 1952—'53, in the important countries of sugar production is given in the next page.

Besides being an important commercial crop, sugarcane in India finds a prominent place in the sugar map of the world, contributing to about 19 per cent of the world output of cane sugar and 12 per cent of the total world sugar. India takes the second place among the sugar producing countries of the world, after Cuba, and the highest place with regard to the extent of cultivation.

Name of country	Production of sugar in long tons	Name of country	Production of sugar in long tons
(*a*). **Cane sugar**		(*b*) **Beet sugar**	
Louisinia	410,000	Germany	1,775,000
Puerto Rico	982,000	Czechoslovakia	700,000
Hawaii	965,000	France	900,000
Cuba	5,070,000	Russia	2,900,000
Br. West Indies	655,700	Poland	1,000,000
Other States	4,465,200	Italy	700,000
		Great Britain	575,000
Total-America	**13,540,200**		
India (*gur*)	3,166,667	**Total-Europe**	**11,276,000**
,, white sugar	1,500,000		
Pakistan ,,	300,000	**U. S. A.**	**1,225,000**
,, (*gur*)	633,333		
Indonesia	500,000	**Total-Beet sugar**	**12,929,000**
Japan	40,000		
Formosa	675,000		
Phillipines	1,185,000		
Total-Asia	**8,000,000**		
Total-Oceania	**1,000,000**		
Total-Africa	**1,585,000**	**Total cane and**	
Total-cane sugar	**24,150,200**	**beet sugar**	**36,779,200**

Sugarcane cultivation is concentrated in parts of Asia and America, where a tropical climate prevails, while sugar beet cultivation is confined to temperate regions, as in Europe and parts of America and Asia.

Distribution. The extent and production of sugarcane in the several States in the Indian Union during the year 1953—'54 are furnished below:

Name of State	Extent in acres	Production of sugarcane in long tons	
	(1,000s)	(1,000s)	per acre
1. Andhra	92	2,880	31·3
2. Assam	62	586	9·5
3. Bihar	256	1,391	5·4
4. Bombay	186	5,229	28·1
5. Hyderabad	57	1,217	21·7
6. Madras	95	2,528	26·6
7. Madhya Pradesh	29	366	12·6
8. Mysore	57	956	16.8
9. Orissa	60	1,009	16·8
10. East Punjab	341	3,570	12·3
11. Uttar Pradesh	2,158	24,846	11·5
12. West Bengal	44	830	13·4
13. Other States	180	2,061	11·5
Total: All-India	3,617	47,469	13·5

Source: *'Agrl. situation in India'*, Jan. 55, p. 705.

Of the sugarcane in India, 81 per cent is in North India beyond 20° N. Latitude, chiefly in the Gangetic alluvial plains of Uttar Pradesh, Bihar and East Punjab, under rain-fed conditions mostly and where the climate is of a subtropical type. Extensive contiguous areas of sugarcane are seen here, while the cultivation is only in

isolated fields in Peninsular India. Sugarcane is planted in March-April in North India. With the onset of the cold weather in October, there is cessation of growth of sugar cane and commencement of ripening. The actual growing period is thus limited to about 6 months. The sugarcanes are of a thin type, hardy, and frost and drought resistant to some extent. The sugar content, the purity of the juice and the yields are low. In spite of these handicaps, large areas are devoted to sugarcane, as the crop is produced at low cost.

Sugarcane in Peninsular India is grown under tropical conditions, mainly in Madras, Andhra and Bombay States, and claim 10 per cent of the total extent under the crop in India. The canes are of a thick, soft type, with a high sucrose content and juice purity. The yield is also higher. They are cultivated intensively under irrigation and make good growth under the climatic conditions that prevail. There is not any marked cold weather as in North India and canes make uninterrupted growth. If they are more than 6 months of age when the dewy season commences in November, they tend to flower and further growth ceases. Crops planted in August-October keep on growing for about 15 months, till the dewy season of the following year. They respond very well to heavy manuring and copious irrigation. Possibilities of increasing cane yields in Peninsular India, particularly in Madras, Andhra and Bombay, by intensifying cultivation and adjusting the time of planting suitably are great.

The normal extent of sugarcane and the standard yield of jaggery in the several districts of Madras and Andhra States are furnished in the next page.

South Arcot, North Arcot, Coimbatore and Tiruchirapalli in Madras, and Srikakulam, Visakhapatnam, East Godavari and Chittoor in Andhra States figure prominently, with about 20,000 acres of sugarcane in each of the districts. The others have varying small areas. The extent under sugarcane fluctuates from year to year, depending upon the price ruling for jaggery at the time of planting the crop.

Madras			Andhra		
District	Extent in acres	Standard acre yield of jaggery in lb.	District	Extent in acres	Standard acre yield of jaggery in lb.
Chingleput	410	6,900	Srikakulam Visakhapatnam	45,620	5,879
South Arcot	24,930	7,360	East Godavari	17,610	8,465
North Arcot	20,290	6,060	West Godavari	9,630	8,534
Salem	13,760	5,992	Krishna	5,540	9,320
Coimbatore	17,750	8,740	Guntur	420	8,395
Tiruchirapalli	20,130	6,160	Kurnool	330	5,040
Tanjore	2,460	6,384	Anantapur	7,920	5,300
Madurai	9,680	6,572	Cuddapah	1,040	6,360
Ramanathapuram	1,690	4,770	Nellore	170	6,360
Tirunelveli	420	6,360	Chittoor	18,410	8,844
Malabar	230	5,346	Others*	10,960	
South Kanara	6,350	5,940			
Total (Madras)	118,100	6,773	Total (Andhra)	117,650	7,150

Source: Madras Govt., *Season and Crop Report of the Madras State for the year 1952 - '53*, 1955; the yield of jaggery is based on the results of crop cutting experiments conducted from 1936 to 40. (* refers to Bellary, now part of Kurnool and Anantapur.)

The sugarcane stubbles are sometimes left on the land and a ratoon crop is taken during the second year in Visakhapatnam, Krishna, Coimbatore and Tiruchirapalli districts. The ratoon crops occupy 1,500 to 2,000 acres in each of these districts and the extent under sugarcane furnished above includes ratoon areas also.

Adaptation. Warm and humid climates are extremely suitable for sugarcane. A mean temperature of 78° F. during the growing period and about 60° F. during ripening appear to be the optimum for sugarcane. Its cultivation is confined 30° south and 37° north of the equator, in the region lying about the isotherm 68° F. It is grown in regions, where the annual rainfall ranges from 40 to 280 inches, supplementing the natural rainfall with irrigation, where necessary. Considerable moisture is required during the period of active growth. Heavy rains and copious irrigation interfere with the ripening of sugarcane during the late stages; the axillary buds are stimulated and ripening tends to be uneven, imperfect and prolonged. The onset of a well defined cold weather is of great assistance in inducing uniform ripening. The climate in South India is very favourable for the growth of sugarcane, but the ripening period is not so well defined as in North India. Summer condition setting in in South India after the period of active growth has nearly the same effect on the ripening of sugarcane, as that of cold weather in North India; there is cessation of active growth and the canes commence ripening.

Sugarcane is not very fastidious in its soil requirements and it is grown in almost all classes of soils, with suitable manuring and irrigation. It prefers and thrives in deep, rich, red or brown loamy soils, which have good

natural drainage. The cultivation of sugarcane is concentrated in alluvial and clay loam regions. Stony and gravelly soils are poor and unsuitable for sugarcane.

Sugarcane can be grown in clayey soils and even in alkaline soils, provided the natural drainage is satisfactory. Though it may grow normally in these soils, it does not ripen properly and glucose persists in the juice at the time of harvest in quantities, which tend to affect the setting quality of the jaggery, its crystalline structure and hardness. Abundance of salts in the soil conduces to the production of sugarcane with juice of low purity, and the resulting jaggery is saltish to the taste. Chlorides affect the setting quality of the jaggery more than other salts. On the other hand, calcareous soils produce sugarcane whose juice is of a high degree of purity.

Drainage. Though sugarcane requires considerable quantities of water for its growth, it does not tolerate stagnation of water. Water logging arrests growth in the early stages and hastens the maturity of cane, when it is fully grown-up. When the supply of water, air or plant food is limited, plants tend to mature quickly in general, in their urge to perpetuate the species.

Sugarcane is often grown in high level wet lands surrounded by swamp rice fields. Suitable arrangements have, therefore, to be made for draining the sugarcane fields thoroughly, by opening ditches all round and also inside the fields.

Classification. There are a large number of varieties of sugarcane under cultivation. The several varieties are grown in a pure state, without being admixed with other varieties. It is also seen that the same variety is grown almost all over each region, except round sugar factories,

and much confusion is not caused by mixing up varieties, which is a common feature with most other crops. Sugarcane varieties were classified by Dr. Barber in the following manner:

1. *Saccharum officinarum* Linn., includes the thick or the 'noble' canes, which are stout, soft and juicy, combined with a luxuriant growth habit. They are not so hardy as the others and require a fertile soil and generous cultivation, manuring and irrigation. The sugarcanes grown in South India are mostly of this group and are under irrigation.

2. *S. barberi* Jesweit., comprises the reed-like thin canes like 'Saretha' and 'Sannabile'. They are hardy, and drought and frost resistant to an extent. The 'Saretha' canes are common in North India, particularly in Punjab, Uttar Pradesh and Bengal and they are seen here and there in South India, along the West Coast and Mysore. The 'Sannabile' canes are also distributed in North India. The 'Nanal' canes of South India are in this group.

3. *S. sinense* includes a number of thin and medium canes, like 'Panshahi', 'Nagori' and 'Mungo' or 'Uba' varieties, which are grown in North India.

4. *S. spontaneum* Linn., is a wild species, which is seen growing in a state of nature all over India and belongs to the same genus as sugarcane. It is, however, not cultivated anywhere. It has been deliberately used for crossing with the cultivated sugarcane varieties at Coimbatore by Venkataraman (Sir T. S.), for infusing hardiness and ability to withstand drought, frost and diseases. Most sugarcane strains released from Coimbatore have this wild blood in their make-up, which has made the Coimbatore canes world famous.

Varietal differences. Sugarcane varieties differ from one another in the colour and hardness of the rind, the habit of growth, the thickness of the stem, the richness and purity of the juice, duration, resistance to pests and diseases and adaptability to varying environmental conditions etc.

The pigments on the stem pass on to the sugarcane juice during its extraction, affect the colour of the jaggery produced and make the clarification of the juice difficult in sugar factories. A dark colour of the stem is a disadvantage. Sugarcanes with hard stems are not subject to much damage by jackals and pigs, and they offer some difficulty in milling. Tillering increases the number of canes in the field and leads to increased yields.

The length of internodes influences the purity of the sugarcane juice. The longer the internode, the fewer are the axillary buds and nodes, which largely give non-sugary material during milling and reduce the purity of the juice. Increase in the thickness of the stem raises the ratio of the juice to the fibrous cellular stem tissues and the purity of the juice.

Indigenous canes. The original indigenous sugarcanes have largely gone out of cultivation in South India. 'Nanal', one of them, is grown in parts of Tiruchirapalli, South Arcot and Chittoor. It is rich in sucrose and gives juice of very high purity.

Exotic canes. A large number of varieties of 'noble' canes was introduced into South India in the past and the more notable of them are (1) 'Red Mauritius', (2) 'Purple Mauritius ', (3) 'Striped Mauritius', called ' Namam ', 'Namalu' and 'Rasthali' in the Central districts of Peninsular India and 'Patta pati' in Mysore, (4) 247 B, later

called 'J. 247', a hardy cane resistant to jackal bite and largely cultivated in the twenties, (5) P. O. J. 2878, styled as the 'Wonder cane' of Java, which is still under cultivation in small areas in South Arcot, Visakhapatnam and Godavari districts, (6) B. 208, a soft cane with a golden yellow rind, introduced from Barbados and called '*Bangara theega*' in Andhra Desa and '*Thanga Kodi*' in Tamil Nad, which is a good chewing cane, extremely sweet to taste and (7) Fiji B, a short, stout, purple cane, with a high sucrose content and purity, and which is popular specially in regions liable to cyclonic winds, where other varieties tend to lodge severely. The several varieties introduced from time to time held the field for some years and gave place to new varieties later, particularly the cross bred Coimbatore or Co. canes.

Sugarcanes are classified as thick, medium and thin canes, depending upon the stoutness of the stem. The thick canes are suitable for cultivation in South India, under irrigation. They make vigorous growth and yield heavily under intensive cultivation. The medium and thin canes are suitable for cultivation under rain fed conditions in North India, where a subtropical climate prevails. It is estimated that the Coimbatore canes occupy about 90 per cent of the sugarcane areas in India, at present.

Coimbatore led the way in the world in effecting intergeneric crosses with sugarcane. Sugarcane was crossed with sorghum and bamboo, though the economic possibilities of the cross-breds have yet to be realised. Co. 351 to 357 are sorghum-sugarcane crosses, which have a short duration. They have not come to general cultivation. Sugarcane has been crossed with teosinte

and a hybrid H. M. 661 has been released for cultivation from Mysore.

Rotations. Sugarcane is cultivated rarely in the same field year after year, except when it is ratooned. It is grown in rotation with rice in wet lands, sugarcane coming in, in alternate years at Bellary, once in 3 or 4 years at Coimbatore and once in 5 or 6 years at Godavari. In garden lands, it is rotated with crops like sorghum, *ragi*, cotton etc. Sugarcane, groundnut-*ragi* mixture, garden land rice and *cumbu* form a 3-year rotation in South Arcot.

Mixtures. Sugarcane is grown generally as a pure crop. When the crop is very patchy, yams are planted in the gaps in the Godavari area. At Coimbatore, onions are planted along with sugarcane in between the rows. *Bhendai* (*Hibiscus esculentus*), redgram and castor are sown along the borders of sugarcane fields in some places. Rarely, sunhemp is sown with sugarcane, pulled out after 2 months and laid along the sugarcane rows, at the time of earthing up the canes.

Season. The main planting season for sugarcane in South India is from February to April. Co. canes are the major varieties under cultivation and they come to flower in November-December, when planted in this season. This limits the period of growth and consequently the yield of the crop. Sugarcane is planted in a second season in July-August in parts of Coimbatore and Tiruchirapalli. The crop is only 4 months old at the time of setting in of the cold season in November and the crop continues to make growth, without interruption by flowering. The crop is 9 months old during summer and makes a heavy demand on irrigation, which limits

the extent of cultivation of sugarcane in this season. The crop matures by August-September, 13 to 14 months after planting and the yield of cane is higher than in the case of the main planting. The 'Adsali' planting of sugarcane is similar to this more or less. Sugarcane is planted from July to September and it is in the field till the cold season of the following year, with a growth period of about 16 or 17 months. It is harvested in December and gives heavy yields. 'Adsali' planting in Bombay and the July-August planting in South India can be adopted, only where adequate irrigation facilities are available during the summer months.

Seasonal planting trials. Sugarcane was planted in all the 12 months of the year in a number of agricultural stations in South India, with the object of determining the season most suitable for planting. The following indications are furnished by these trials:

1. The best time for planting sugarcane in South India is January to April, the earlier the better,

2. late planted sugarcane is liable to borer attack in the months of May and June,

3. sugarcane makes active growth from June to September, with but little growth later,

4. most varieties arrow in November, but mature only in January-March,

5. sugarcane starts deteriorating 6 to 8 weeks after ripening,

6. sugarcane planted in September or later may be harvested in December of the following year or later, after 15 months or more,

7. germination of sugarcane is very slow during cold weather, and

8. sugarcane, planted in June or later, does not arrow during the year.

Preparatory cultivation. Sugarcane is given a thorough and deep preparatory cultivation. In Godavari, the lands are dug deep, allowed to weather and the clods are broken with mallets later. They are then ploughed repeatedly till a suitable tilth is obtained.

In Visakhapatnam, the land is ploughed well, manured with cattle manure and laid into ridges and furrows finally.

In North and South Arcot districts, trenches are opened 3 feet apart, without any preliminary ploughing and left for weathering. They are 12 inches wide and 9 to 12 inches deep. The bottom of the trenches is loosened by digging.

In Coimbatore, the fields are ploughed a number of times, and ridges and furrows are formed 2½ to 3 feet apart, with spades.

In parts of Madurai, trenches are opened in the field, 3 to 4 feet apart and pits 6 to 8 inches square are dug along the trenches 1½ to 2 feet apart, for planting sugarcane. This method of planting is known as '*kuli karanai*' in Tamil Nad and '*gunta mutchi*' in Andhra Desa.

In parts of Godavari, water is let into wet lands at the time of planting sugarcane, the stubbles of the previous rice crop are pulled out and the sets are pressed into the soft mud, without any preparatory cultivation.

When the fields are moist and not suitable for ploughing in the dry state in the Circars, they are puddled

after letting in water and the cane sets are planted in the puddle. The fields are hoed later, when they dry up.

It may be enough if the lands intended for sugarcane are ploughed 2 or 3 times with a medium sized mouldboard plough and ridged up. It will be more economical than digging the soil or ploughing it a number of times to produce a fine tilth.

Seed material. Sugarcane is propagated vegetatively, by planting small lengths of stem, called 'sets'. The cut ends of the sets are not allowed to project more than ¾ inch from the extreme nodes, as they may otherwise attract termites, and be also subject to fermentation and lead to spoilage of the sets. Each set is 7 to 9 inches in length and has at least 3 live buds. Varieties with short internodes may have more buds.

The top portion of the sugarcane stem is relatively young, when compared to the basal portion. The buds on the former are young and active and start growth readily after planting, while those on the latter are aged, and dormant and do not grow so readily. It is, therefore, preferable to use the top one third portion of the cane for sets and utilise the rest for milling. It is advantageous from the point of production of jaggery also. The top is poorer in sugar than the bottom, and the use of the top for sets and the bottom for milling will give a higher yield of good jaggery.

The sugarcane clumps are cut one after another for making sets and the individual canes on each clump have to be examined for mosaic and red rot. Only clumps, in which all the canes are free of diseases, should be used for the production of sets. When a diseased clump is cut, it has to be rejected and diverted for milling and the cutting

knife sterilised by dipping it in copper sulphate solution, before using it again for cutting sugarcane clumps afresh.

The sugarcane sets are next pickled in copper fungicidal solutions, like 'wetcol' at 1 lb. in 20 gallons of water, or 'perenox' at 1 lb. in 40 gallons of water, as a protection against fresh fungal infection through the cut ends. Where the sets are liable to termite damage, the furrows may be dusted with 5 per cent B. H. C., at 20 to 30 lb. to the acre.

One hundred sets weigh on the average about 35 lb. with thin canes, 45 lb. with medium canes and 55 to 60 lb. with thick canes.

Planting and harvest of sugarcane are done at the same time in Tamil Nad and the top part of the cane is used for the production of sets and the basal part is milled. The entire cane is often cut into sets in Andhra Desa. Harvest precedes planting in many areas and a small part of the crop is left uncut, to provide seed material later, at the time of planting. These are called 'stand-overs'. Where the crop is kept over for a long time in the field, the top part of the sugarcane gets dry and the seed material obtained is of poor quality.

In parts of Kurnool, sugarcane is cut into lengths of 1½ to 2 feet, dipped in mire, and kept heaped and covered with straw or cane trash. They remain in a condition fit for planting for about 1½ months. This is referred to as the 'Kurnool method' sometimes. This has not proved satisfactory at other places.

Short crops. Sugarcane sets are planted close to one another in furrows, 2½ feet apart. The crop is manured before planting in February and also a second time 2½

months after planting. The crop is 6 to 8 feet high by August, after a period of 6 months. It is cut and made into sets for planting a fresh area 7 to 8 times the original area. The multiplication of the set is 10 to 12 fold, that is, 10 to 12 sets are produced for each set planted originally, on the average. The second season is not so favourable for the growth of sugarcane and this crop produces 5 or 6 sets on the average for each set planted after a period of 6 months. By raising 2 short crops, one after the other, the sets can be multiplied 60 to 80-fold. The short crop sets are immature, and all the buds are active and germinate readily. They are also free of diseases and can be produced conveniently.

Gormandiser sets. Late sugarcane tillers are very vigorous and extremely stout in certain varieties like P. O. J. 2878 and they are called 'water shoots', or 'gormandisers'. They are immature at the time of harvest and reduce the purity of the juice, when milled with mature canes. They are, therefore, left in the field in parts of Visakhapatnam and cut into sets at the time of planting. The gormandiser sets are as satisfactory as short crop sets and this system may advantageously be followed, where feasible.

Transplanting canes. In parts of Ganjam, sugarcane is planted in August and harvested in May for the production of jaggery. If the crop is kept over till the next planting season in August, it gets dried up and unsuitable for planting. A part of the crop, sufficient for providing sets for the next crop is, therefore, cut in February, made into sets and planted close in a nursery, called '*gonda manji*'. The seedlings are uprooted from the nursery in August and transplanted in the main field.

This is the only region, where a sugarcane crop is established by transplanting rooted sets; fresh stem cuttings alone are used in other places.

Windrowing canes. Sugarcane buds are injured by frost prevailing in North India, during November-December, particularly in Punjab. The sugarcane plants intended for seed are then pulled out with the roots, laid in pits, and covered with trash and earth. The canes are kept in the pits for 2 to 3 months, till there is the danger of frost. This is called the 'windrowing' of sugarcane.

Systems of planting. Four main systems of planting sugarcane prevail in South India, namely (1) the flat bed system, (2) the ridge and furrow system, (3) the trench system and (4) the pit system.

1. *The flat bed system.* This is the system commonly practised in the Godavari delta. The lands are ploughed, manured and laid into long beds, by opening furrows, 5 to 6 feet apart. The beds are flooded with canal water and the excess water is drained after the soil gets soaked sufficiently. Sugarcane sets are distributed over the field and trampled into the mire. The furrows between the beds are deepened after a month and made into trenches, for facilitating the drainage of the stiff clayey soils. Twenty to thirty thousand sets are planted in an acre.

2. *The ridge and the furrow system.* This is the common system prevailing in other tracts. Furrows are opened $2\frac{1}{2}$ to 3 feet apart, the sets are distributed over the ridges and later pressed into the furrows after letting in water. The sets are planted with the buds on the sides to enable the germination of all the buds on the sets. If they are planted with the buds on one side facing upwards,

the buds on the opposite side point downwards and these cannot get round the canes and come to the surface. The sets are planted in the direction of the furrows, across or even slantingly, 12 to 18 inches apart from centre to centre and each yard of the furrow takes 2 or 3 sets. When the furrows are 3 feet apart, 10,000 sets are required for planting an acre, with a spacing of 1½ feet between them and 15,000 sets with one foot spacing.

3. *The trench system.* This is very similar to the ridge and furrow system, but trenches 1 to 1½ feet deep and 3 to 4 feet apart, are formed instead of the furrows and this is in vogue in the Nellikuppam sugar factory area. The trenches are made with manual labour and the bottom of the trench is loosened by digging. It is more convenient to open trenches with medium sized mouldboard ploughs. Irrigation, weeding and application of fertilizers are confined to the trenches. These get filled up gradually and are closed completely, when the canes are earthed-up after manuring. The sets are planted as in the furrow system and some extra sets are planted at the ends of trenches for providing rooted sets to fill up gaps later, if necessary.

4. *The pit system.* Small pits are dug 3 feet apart each way and 2 sets are planted in each pit. They are pot watered till water becomes available in the irrigation channels, when the field is flooded as in the bed system. Drainage channels are opened, where water is liable to stagnate in the fields.

The bed and the pit systems are adopted, where drainage is a problem after receipt of water in the irrigation systems. Deep trenches are opened between the beds for facilitating easy drainage. The ridge and furrow system

of planting is adopted with the lighter types of soils. It promotes the formation of a good root system and is of assistance in reducing lodging of the crop to a certain extent. There is economy in the use of irrigation water. It is suitable for heavy soils also and can facilitate the drainage of surplus water from the surface of the fields, though it is not ordinarily adopted. The trench system is particularly suitable for very light soils. Earthing-up the canes is done more throughly here than in the ridge and furrow system and the feeding roots are at some depth from the surface. The crop is enabled thereby to stand drought extremely well. Cultivation and manuring are confined to the trenches in the early stages of growth.

The number of sets used for planting an acre ranges from 10 to 30 thousands and 2 to 6 tons of canes are required. The average yield of sugarcane in South India is about 28 tons per acre and a fair part of the sugarcane produced has to be diverted for planting. It emphasises the need for economising seed material. But it has also to be remembered that it is equally necessary to obtain a satisfactory stand of the crop from the beginning itself and it is bad economy to stint on sets and get low yields.

The fertility of the soil and the tillering capacity of the variety of sugarcane have a large bearing on the number of sets used for planting. If the land is fertile and there is good tillering, a low set-rate will suffice. When tillering is active in the early stages of growth, late tillering is not conspicuous. The crop is then uniform and all the shoots come to maturity together and this contributes to the purity of the sugarcane juice. With varieties which have a protracted tillering habit, a high set-rate is necessary to enable the land being covered by

early tillers and to discourage any tendency to develop late tillers.

No hard and fast rules can be laid down regarding the correct set-rate. The correct set-rate gives a good stand of the crop, which covers the ground within about 3 months of planting and keeps down the subsequent tillers, if any are formed. When sets are prepared from young growths, the buds are active and 15,000 sets will normally be sufficient for an acre, particularly with the Co. canes, which tiller freely.

Manuring. Sugarcane is a vigorous crop and makes a large demand on plant food. A 30-ton crop removes from an acre of land the following ingredients of plant food :

Plant food elements -	N	P_2O_5	K_2O	CaO
Quantity removed in lb. per acre -	69·7	132·8	261·3	265·6

Source: Parthasarathy, S. V., '*Planning manurial experiments in sugarcane in Madras State*', Mad. Agric. Jl., 1952, XXXIX. 3., p. 138.

It is remarkable that even though large quantities of the various plant nutrients are removed by the sugarcane crop, the responses to the application of the several nutrients are not the same. Thus, potash and / or phosphates do not influence the yield or quality of sugarcane in South India, though there is a general impression that phosphates improve the setting quality of jaggery. On the other hand, sugarcane responds very well to nitrogenous manuring. Quick acting manures and fertilizers are more efficient than slow acting manures. Thus, 10 bags (1,660 lb.) of castor cake give a better response than even 30 tons of cattle manure. The value of cattle manure as a supplier of nitrogen is not much. It does not influence

markedly either the quality of the juice or the yield of sugarcane, as is commonly supposed. On an equal nitrogen basis, ammonium sulphate gives a better response than oil cakes. Ammonium sulphate which has all its nitrogen in an available form may be combined with oil cakes which make their nitrogen available, slowly and at a steady rate. The combination serves to regulate the level of available nitrogen in the soil. The juice quality is depressed, when the level of available nitrogen in the soil is increased, beyond certain limits. The ratio of ammonium sulphate nitrogen to cake nitrogen, which has been found suitable in actual practice ranges from 1 : 1 to 2 : 3.

Experiments indicate that the quantities of nitrogen repuired by the sugarcane crop in the different tracts in South India are as follows :

Anakapalli region - 100 lb. of N, per acre,
Samalkota region - 150 lb. of N, per acre,
Gudiatham region - 200 lb. of N, per acre and
Palur region - 250 lb. of N, per acre.

The requirements of nitrogen is very varying in the different regions. Similar variations in requirements may be expected even between different fields in the same locality. Any recommendation made with regard to the quantity of manures and fertilizers for sugarcane can only be of a general nature and not specific for each field. Previous experience of individual fields has to serve as a guide. A dose of 150 lb. of nitrogen gives a 30 ton crop on the average, which removes about 70 lb. of nitrogen from an acre of soil.

The particular dose of manure which gives the best results is influenced by (1) the soil conditions and fertility, (2) the climate, including rainfall and the irrigation

FIG. 36. Planting sugarcane sets.
Water is let in trenches and the sets distributed on ridges are planted in the trenches.
—*Courtesy: Messrs Parry & Co. Ltd., Nellikuppam.*

Fig. 37. Applying fertilizers to sugarcane and covering.
—*Courtesy*: *Messrs Parry & Co. Ltd., Nellikuppam.*

FIG. 38. Green manure intesrown in sugarcane being pulled out for application.

—*Courtesy*:—*Director of Agriculture, Madras.*

FIG. 39. Wrapping and propping sugarcane in Northern Circars.
Courtesy:—Director of Agriculture, Andhra State.

FIG. 40. A trashed sugarcane crop.

Courtesy:—Messrs Parry & Co. Ltd., Nellikuppam.

facilities available and (3) the variety of sugarcane planted. Lands of average fertility may be manured with 10 tons of cattle manure, 250 lb. of ammonium sulphate and 700 lb. of groundnut cake to an acre.

Time of application of manures. The application of the entire quantity of manure at the time of planting sugarcane is not conducive to the highest yields obtainable. The manures are best applied in 2 or 3 doses, one 45 days after planting and the other/or others within the first four months. The crop requires large quantities of nitrogen from 2½ to 5 months from the time of planting, and the nitrogen applied becomes available in full 1½ months after application. Nitrogen is not required in large quantities beyond 5 to 6 months of planting. If manure is applied after 4 months of planting, the absorption of nitrogen by the crop continues, there is increase of nitrogenous colloids and reducing sugars in the juice, and the cane does not mature properly and in time. If large quantities of nitrogen are made available in the early stages of growth, up to 2 months of planting, they are not fully utilised by the crop and are wasted. Light early manuring in poor loamy soils is helpful.

Green manure for sugarcane. This is an aspect that has not received much attention in the past, though its possibilities have been indicated in various parts of India at different times. Green manuring is particularly advantageous, when fertilizers sell at high prices. There should preferably be an interval of 2 months between the ploughing-in of the green manure crop and the planting of sugarcane, and sufficient moisture in the soil to decompose the green manure properly and make its nitrogen available for the cane. A sunhemp crop may

be expected to add 60 lb. of nitrogen to the acre, when it is about 50 days old. The interval between the previous crop and sugarcane is often short and the moisture in the soil is not sufficient to permit a green manure crop being raised in most cases. Sunhemp seeds may then be dibbled in between the rows of sugarcane at the time of the first weeding and the sunhemp crop pulled out when it is 50 days old and applied to the cane rows and earthed-up. There is no practical difficulty in inter-sowing sunhemp under South Indian conditions, where sugarcane is raised under irrigation and the availability of moisture in the soil is not a limiting factor.

Irrigation. The sugarcane crop has a luxuriant habit of growth and requires large quantities of water. When the natural rainfall does not provide sufficient moisture for the crop, irrigations are given at suitable intervals. Sugarcane requires 80 inches depth of water for its growth, inclusive of the rainfall during the period. Light loamy soils require more water than clayey soils. Sugarcane is given 15 to 18 irrigations in the heavy soils of Godavari, 20 to 25 irrigations in the clay loams of Coimbatore and 30 to 35 in the light soils of South Arcot.

The trench system and the ridge and furrow system require less water, than the bed system, where the fields are flooded with water during irrigation. In the pit system, there is considerable saving of water in the early stages, when pot watering is done, though later, the entire field is flooded and the water requirements do not then differ materially from those of the bed system.

After-cultivation. This consists of (1) hoeing and weeding, (2) earthing-up, (3) mulching, (4) wrapping and propping and (5) trashing.

1. Hoeing and weeding. Weeds spring up with the sprouting sugarcane and suppress the growth of the young crop. The fields are therefore worked with hand hoes and the weeds are removed twice or thrice at suitable intervals, when necessary. The crop gets vigorous by this time and is able to suppress the weeds that spring up later, effectively. The inter-furrow spaces in row crops are worked with bullock cultivators, like the Junior Hoe and the furrows are hand hoed. Later, the sugarcane rows are earthed-up, which covers the manures applied at the base of the plants.

2. Mulching. In the Visakhapatanam region, the sugarcane crop is weeded 4 times, before the channels are closed in April, for the annual clearance of silt. The trenches are then deepened for facilitating drainage of the fields and the beds in between the trenches are covered with cane trash, which serves as a mulch and prevents the surface soil from getting heated up unduly during summer, which is very severe here. The mulch is removed and the fields are flooded with water, when the channels are opened for irrigation in June.

3. Wrapping and propping. In the Godavari region, the dry leaves at the base of the sugarcane plants are wrapped round the stem from July onwards. At the time of the first wrapping, bamboo uprights are planted along rows in the field, in between every 2 or 3 clumps. About 5,000 bamboo poles are required for an acre. The second wrapping is done after a month in August and the sugar-cane clumps are then tied to the bamboo uprights planted earlier. Three clumps are brought together near the top and tied to each pole. When the third wrapping is done in September, stout bamboo poles are fixed

between rows, and the clumps are wrapped to them, in addition to their being wrapped to the bamboos along the rows. About 1,000 bamboos to an acre are required for the purpose. Three more wrappings are done at intervals of about a month. When the crops are beyond the reach of men, tripods are used for hoisting them up, while wrapping and propping. The last wrapping is done in December not only to assist propping, but also to arrest further growth and hasten maturity. So, the tops of canes are brought close together in each clump and tied to the central stout bamboo poles. In Mysore, the sugarcane is wrapped and the tops of 3 or more adjacent clumps are brought together and tied to one another without bamboo props and this is effective in preventing the heavy canes from lodging.

Sugarcane rows can also be propped by stretching thin wires along both the sides of the rows and securing them to bamboos fixed vertically at the ends of the rows. If the rows are maintained constantly at a length of about 40 to 50 feet, year after year, the same set of wires can be used in the subsequent years also. Bamboo poles last for 3 or 4 seasons and the wires for 12 to 15 years.

Wrapping is done primarily to facilitate propping in regions, where winds tend to lodge the canes. Besides, it protects the cane stems and prevents them from cracking in the sun's heat. The dry leaves of sugarcane have bristly edges and discourage jackals from biting and damaging the stems, which is particularly valuable with soft stemmed canes. Varieties having dark coloured stems do not develop the full depth of colour when wrapped and the jaggery produced is consequently a little lighter in colour. Wrapping the crop 6 times

requires about 100 men for an acre and it is a costly operation. It is not prevalent in regions, where canes do not lodge, as in Tamil Nad.

Propping is necessary in regions, where heavy and tall canes tend to lodge severely. Cyclonic winds develop in the Godavari region during the north-east monsoon season and lodge the sugarcane crops, when they are not propped suitably. Lodged canes strike roots at the nodes, which contact the soil and this promotes fresh growths from the axillary buds. The maturity of the canes becomes uneven and the juice quality is impaired. Further, the stems broken during lodging are liable to red rot, which increases the acidity of the juice, lowers the sugar content, and interferes with the setting quality of the jaggery.

4. *Trashing.* This consists of stripping the lower dry leaves on the sugarcane stem. Water collects between the loose dry leaf sheaths and the stem during rainy weather and stimulates the axillary root eyes and buds to activity, which interferes with the ripening of the cane. Trashing is, therefore, done in regions where the sun is not very severe and where rains are heavy and frequent.

Ratooning sugarcane. Sugarcane can be ratooned for 2 or 3 seasons. The plant crop of sugarcane is cut close to the ground at the time of harvest, when it is proposed to ratoon and take a second crop from the same planting. The waste trash and dry leaves can be incorporated with the soil or composted and applied to the land. The field is irrigated soon after harvest for stimulating the cane stools to sprout and send up fresh shoots. The crop that comes up is called the 'ratoon crop' and it is treated like the plant crop. Ratooning appeals to farmers, as the

cost of preparatory cultivation and planting is saved. Thin canes ratoon better than thick canes in a general way and this may partly explain why ratooning is common in North India and not to the same extent in South India. The ratoon crop does not make as much growth as the plant crop and is liable to diseases to a greater extent. The yields of ratoon crops are lower, but since the cost of cultivation is less, the profits obtained may often be as good as with plant crops. Ratoon crops come to harvest earlier than plant crops, and supply of sugarcane to sugar factories can be started earlier in the season and the factories can thus be kept working for a longer season by having some extent of sugarcane under ratoon crops.

The composition of sugarcane. The sugarcane stem is composed of a fibrous cellular skeleton or frame work, holding sugarcane juice. The juice is extracted by milling the cane stems. The following may be taken to be the average composition of sugarcane juice:

Constituents	Sugarcane[1]	Sugarcane juice[2]	
Water	74·50	81·00	
Ash	0·50	0·29	
Fibre	10·00		
Sucrose	12·50		
Dextrose	0.90	18·36	19·00 (brix)
Levulose	0·60		
Nitrogenous bodies	0·40		
Fats and waxes	0·20		
Pectins	0·20	0·35	
Free acids	0·08		
Combined acids	0·12		

Source: 1. Guildford Spencer D., *A hand book for cane sugar manufacturers and their chemists,* 1912.
2. Ghosh H.H., *Sugar in India,* 1934.

The fibrous matrix left behind after the extraction of the juice from sugarcane is called 'megasse' or 'begasse.' The begasse contains a variable quantity of sugarcane juice, depending upon the method of extraction. The fibrous content is also variable. It may be as low as 10 per cent with soft canes and 12 to 14 per cent with hard canes.

The central pithy portion of the internodes contains little of fibre and is surcharged with sugarcane juice, with a small amount of non-sugary impurities. On the other hand, the rind and the nodes have more fibre, less juice and more non-sugary impurities. The juice of soft canes with long internodes is of high purity. In sugarcane which have short internodes, the juice has more impurities comparatively.

Cane sugar is called 'sucrose' and sugarcane is valued for its sucrose content only. It is sweet to taste, crystalline and non-hygroscopic. The presence of reducing sugars, acids and mineral salts in the sugarcane juice tends to affect the crystallisation of sucrose to an extent. The sucrose content of sugarcane juice is a varietal character and it may range from 13 to 23 per cent. Sugarcanes having 12 to 15 per cent of sucrose in the juice are classed as poor, those having 16 to 19 per cent as fairly rich and those having over 20 per cent as rich canes.

The quantity of 'total solids' in sugarcane juice is determined with a special hydrometer, called 'brixometer', calibrated to read off directly the percentage of total solids in the juice, called 'brix'. The brix reading may range from 18 to 22. The total solids in the juice of young and immature canes may be as low as 15 per cent. It rises as the cane matures and may go up to 22 per cent with very rich canes. The ratio of sucrose to total solids,

expressed as a percentage is called the 'coefficient of purity'.

The other sugars present in the sugarcane juice, that is, dextrose and levulose, are reducing sugars, which are referred to as 'glucose', commonly. They are mildly sweet, non-crystalline and hygroscopic in nature, levulose being more hygroscopic comparatively. They induce softness in the jaggery. When the glucose content is high, jaggery does not set properly and it is plastic in consistency.

Glucose is presumably the sugar, which is first formed in sugarcane and the sugar in young tissues is made up of glucose. As the cane matures, the glucose content decreases rapidly and may be less than 0·5 per cent, when the cane is ripe and mature. The transformation of sucrose back to glucose, either in the sugarcane or its juice, is referred to as 'inversion'. It takes place in the crop when it lodges, leading to the development of roots and shoots from the nodes. When the crop is kept in the field after maturity, there is slow inversion and this is called 'over-ripening'. The deterioration of the sugarcane by inversion is rapid in certain varieties, which have therefore to be milled immediately after ripening. Certain varieties get over-ripe only slowly and they may be kept on in the field for about a month or two, without much deterioration. They are valuable and enable the regulation of supply of sugarcane to factories over an extended period and also for making jaggery, when large areas are cultivated.

Damage by jackals, pigs and red rot increases the acidity of the juice in sugarcane, thereby preventing the proper ripening of the standing canes and promoting inversion in harvested canes, before milling.

The mineral matter in sugarcane consists chiefly of phosphates, sulphates and chlorides of calcium, potassium and sodium. Its content is high with immature canes and low with mature canes. Its presence interferes with the proper setting of the jaggery. The chlorides in the juice promote inversion and impart a saltish taste to the jaggery. Chlorine in the soil and irrigation water besides increasing the chlorine content of the juice, increases the intake of nitrogen by the crop and the nitrogenous substances in the juice as well, which have a deleterious effect on the colour of the jaggery.

Nitrogen compounds, pectins and gums are present in the juice in the colloidal state and they interfere with the clarification of the juice during boiling and proper setting of jaggery. Albuminoid nitrogenous compounds get coagulated and form the scum carrying other suspended impurities along with them, when the juice is brought to the boiling point.

Succinic, aconitic and oxalic acids constitute the main free acids in sugarcane juice.

Sugarcane juice is light grey to dark green in colour due to the presence of (1) chlorophyll, which is insoluble and easily removable with the scum, (2) anthocyanins, constituting the colouring matter of the rind and (3) polyphenols or tannins, present mainly in the growing portions, buds and nodes. The tannins get darkened on coming into contact with iron rollers in the crushing mills and the atmosphere. The oxidases present in the juice acting on the tannins impart a light brown tint to the juice.

Signs of ripening. Sugarcane ripens and gets ready for harvest in 10 to 14 months in South India, depending

upon the variety and the season of planting. The mature crop is of a light pale green colour. The internodes at the top do not make much growth and are extremely short, with the result that the top leaves get bunched together and present the appearance of a crown, as in palm trees. The old stem portions may crack in certain varieties. The colour of the stem turns yellow in varieties, which have a light pale coloured stem. The buds near the base start drying. When the cane stems are struck with the back of a knife, mature stems give a metallic sound, while immature stems give a thudding sound. The juice on the surface of the cutting knife is sticky to the feel. These are the field characters of ripe canes and the ripeness has to be confirmed by making a trial boiling. The crop is harvested over a small area, milled and the juice is boiled into jaggery. Mature canes produce jaggery, which sets readily, has a light colour and is hard in consistency and crystalline in structure.

Flowering is not a sign of maturity of the sugarcane stem and the cane is not necessarily fit for milling, immediately after flowering in November-December. It takes a little more time for the canes to mature, and the crop gets ready for harvest by January, February or March. When droughty weather intervenes meanwhile, the cane plant commences drying from the top downwards and the top internodes get dry and pithy.

Top-bottom ratio. When sugarcane ripens, the total solids, the sucrose content and the density of the sugarcane juice increase. The increase commences from the bottom and moves upward progressively. The density of the juice near the shoot in the growing sugarcane is low, and high near the base of the plant. When

the sugarcane is ripe and mature, the density of the juice is nearly the same throughout. The density differences between the juice of the top and bottom halves of the sugarcane is, therefore, a measure of its ripeness. Immature sugarcanes exhibit great density differences. The ratio of the density of the juice of the top half of the sugarcane to that of the bottom half is called the 'top-bottom ratio.' The mid-point of the cane is determined by balancing it on the forefinger, the two halves are cut and milled separately and the brix readings of both the juices are taken for the determination of the ratio. When it approches unity, the cane is said to be ripe and ready for milling. In immature canes, the top-bottom ratio is less than unity and the lower the ratio, the greater is the immaturity.

When the cane is fiept in the field after ripening, deterioration sets in and there is a fall in the density of the juice. The fall is greater in the bottom than in the top ones, with the result that the top-bottom ratio tends to exceed unity. Such a cane is said to be over-ripe and has to be milled before it deteriorates further. Both unripe and over-ripe canes are not quite suitable for milling and the manufacture of good jaggery, or sugar.

The purity of the juice. The coefficient of purity of the juice increases with ripening and it is at its maximum when the cane is fully mature. This maximum varies with the variety and it is higher with rich canes than with poor canes. Sugarcane with a coefficient of purity of about 85 to 90 is ready for milling.

Harvesting. The sugarcane crop is given a good soaking irrigation before harvest, for facilitating the free

extraction of the juice. The canes are cut at ground level with knives and hatchets, the leaves are stripped and the immature tops are removed. These represent the 'millable cane'. Cutting the immature top requires a little judgement. The few top internodes are immature and contain a little sugar and large amounts of salts and non-sugars. Their inclusion in the millable cane lowers the quality of the juice and renders jaggery making difficult. If, on the other hand, too many internodes are rejected, there is loss of recoverable sugar. The leaf sheaths enclose the stems rather fast and cannot be separated easily from the immature top portions of the canes. These can be rejected safely. The cane top provides one terminal set enclosed by leaf sheaths, and one or two immature and tender cane sets can also be cut for planting in areas, where harvesting and planting are done simultaneously. The green leaves of the harvested canes provide green feed for cattle at the time of harvest.

Harvesting is done in many regions by professional jaggery makers, who cut the canes, mill them, boil the juice on contract and receive payment on the quantity of jaggery made. Jaggery making applicances are available for hire in sugarcane regions. The farmers themselves hire these in certain cases and make jaggery, engaging trained labourers.

Milling canes. The juice in the harvested sugarcane is liable to undergo inversion. The exposure of the cut canes to sun light and heat promotes active inversion. The harvested canes have, therefore, to be kept covered with trash and moistened by sprinkling water occasionally to keep down inversion. In any case, sugarcane has

to be milled and made into jaggery as soon after harvest as possible, to avoid deterioration of the cane during the storage period and loss of sugar. The cutting of the cane has to be limited to what can be milled and made into jaggery in a day. Transporting canes from the field to sugar factories over some distance takes time and the canes deteriorate in proportion to the time elapsing between harvesting and milling. This is unavoidable.

Sugarcane juice is extracted in farms with bullock driven sugarcane crushers and rarely with power crushers. Bullock crushers extract juice to the extent of 60 to 65 per cent on the weight of the canes. Power crushers extract up to 70 per cent of the juice. In sugar factories, the cane is successively passed through several sets of rollers, moistening the residual material with water, before passing it on to the next set of rollers. This is called the 'maceration' process of extraction and the sugar present in the cane is almost completely extracted by it.

If it is presumed that a sample of sugarcane contains 12·5 per cent, of sucrose, 10 per cent. of fibre and 90 per cent. of juice, and that 66 per cent. of juice on the weight of cane is extracted, the begasse is 34 per cent. Out of the 90 parts of juice in the cane, 66 parts are extracted and 24 parts are left in the begasse. If it is further presumed that the extracted juice and the juice left in the begasse are of the same composition—which is not correct—, a 30 ton crop will lose in its begasse $\frac{12 \cdot 5}{100} \times \frac{24}{90} \times 30$ or one ton of sucrose. This loss has to be minimised. It is, therefore, important that sugarcane crushers have to be maintained in an excellent condition, with the

rollers adjusted properly, to enable the maximum extraction of the juice.

Fresh sugarcane juice is acidic, with a pH of about 5·4 and is subject to fermentation by bacteria and other organisms on keeping. The fermentation that takes place is of 3 types, namely (1) alcoholic fermentation, (2) lactic and butyric fermentation and (3) gummy fermentation leading to the formation of dextrosans. If sugarcane crushers and the utensils used for keeping the juice are not cleaned each day, the organisms that cause fermentation are carried over from day to day to the fresh juice and conditions suitable for the promotion of fermentation will prevail. The crusher and utensils used for keeping the juice and boiling the jaggery have, therefore, to be cleaned daily, preferably with boiling water.

A bullock driven mill can crush 350 to 450 lb. of sugarcane in an hour and produce 225 to 290 lb. of juice depending upon the efficiency of extraction and the type of cane. Sufficient juice for a boiling is obtained by crushing sugarcane for 2 to 3 hours. The juice is subject to fermentation and has to be boiled as soon after milling as possible. All the juice required for one boiling has to be collected, poured into the boiling pan and the boiling commenced immediately. It is not advisable to start the boiling with a small quantity of juice and add fresh juice in instalments, as the milling proceeds. It will then prevent the proper formation of scum and make its complete removal difficult and impossible.

Boiling the juice. There are 3 definite stages in the boiling of the juice, namely (1) defecation of the juice, (2) evaporation of the juice and (3) concentration of the syrup finally.

1. Defecation. Sugarcane juice is poured into the boiling pan, through a wicker basket lined with coarse cloth, which acts as a filter and retains pieces of begasse, bits of cane and trash that may have got into the juice at the time of crushing. Milk of lime is added to the filtered juice at one ounce or more for every 100 lb. of juice, depending upon the acidity of the juice. Juice of 85 per cent purity requires light liming and one of 80 per cent purity requires heavy liming before jaggery can be made. The juice has to be slightly acidic, with a pH of 6·0 to 6·4 and not alkaline at the time of commencing boiling. An alkaline juice gives rise to a dark coloured jaggery.

The lime added to the juice acts in many ways. It neutralises the acids in the juice, which can otherwise bring about considerable inversion. It combines with the phosphates present and produces a bulky precipitate, which floats with the scum carrying with it a certain amount of colloids. The precipitate can be made bulkier with refractory juices by the addition of phosphoric acid and lime later for neutralising it. Lime effects the precipitation of a certain amount of gums and pectins also. It combines with the glucose in the juice and produces calcium gluconate, which gets caramalised during the concentration of the syrup in the last stages. This tends to darken the colour of the jaggery and improve its consistency at the same time. The quantity of lime added is in a way related to the market demand. Dark coloured jaggery has a hard consistency and it keeps well in humid regions like Malabar without running into liquid, while light coloured jaggery absorbs moisture and gets liquefied. Other markets prefer light coloured jaggery, and the consistency of the jaggery is only a secondary consideration. Heavy liming gives rise to a dark

coloured jaggery and light liming to a light coloured jaggery.

The juice is boiled in flat iron or copper pans, which have vertical or sloping sides. The shape and size of the pan varies from region to region. About 400 to 800 lb. of juice can be boiled in a pan at a time, depending upon its size. The furnace used for boiling was originally a circular pit dug in the ground for holding the boiling pan and an opening for feeding fuel. There was no chimney or outlet for the smoke to escape. Even ash could not be conveniently removed. It required large quantities of wood fuel, in addition to the dry leaves or trash and begasse provided by the cane crop. Considerable improvements have been effected in the furnaces, in use at present. The 'Sindhwahi' furnace is in common use now, and a plan and sectional view of it are furnished in the following sketch.

The Sindwahi furnace is convenient and suitable for boiling sugarcane juice. Sugarcane trash and begasse obtained by milling canes serve as fuel and additional wood fuel is not required. The feeding regulates the heating of the pan, which is, therefore, under control. The boiling premises are free of smoke and heat.

When sugarcane juice is heated and brought to near boiling, the albuminoids present get coagulated and rise to the surface as a thick scum. The scum enfolds considerable colloidal matter, colouring materials, waxes etc. The feeding of the furnace is suspended temporarily, to enable the scum to rise *en-masse* and get firm, without being broken up and dispersed in the juice by boiling or simmering of the juice. The scum is removed with perforated ladles and transferred to a filter basket lined

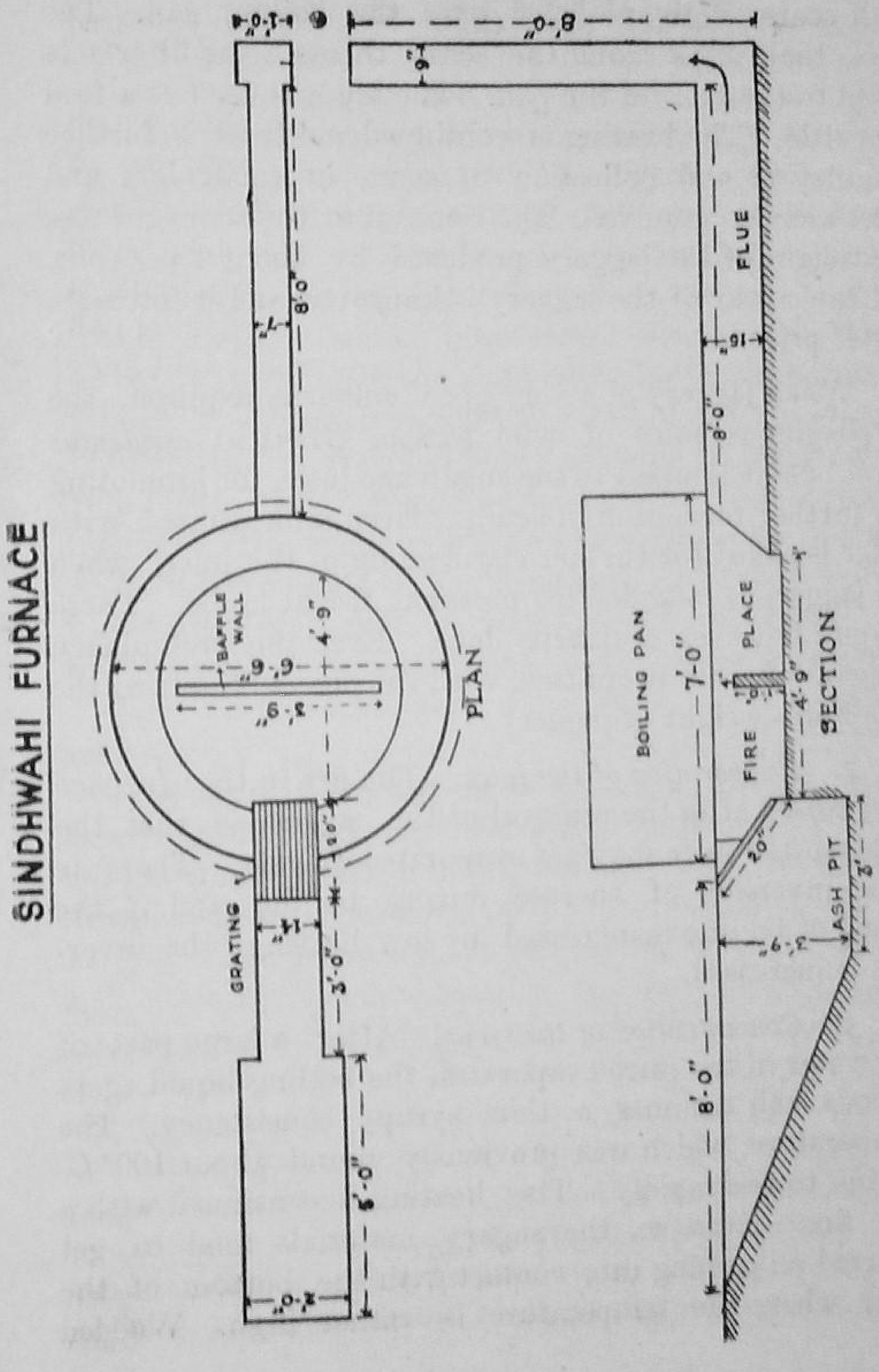

FIG. No. 41. Plan and section of the Sindhwahi furnace, from leaflet No. 29 of 1931 of the Madras Agricultural Department.

—*Courtesy: Director of Agriculture, Madras.*

with coarse cloth and fitted over the boiling pan. The juice that drips from the scum through the filter gets added to the juice in the pan. The scum is used as a feed for cattle. The heating is continued and there is further coagulation and collection of scum in small lots and these are also removed. The removal of the scum reduces the weight of the jaggery produced by about 1 per cent, but the colour of the jaggery is improved and it fetches a better price.

When jaggery of a very good colour is required, the mucilaginous juice of wild *bhendai* (*Hibiscus esculentus* Linn.) plant is added to the sugarcane juice, for promoting the further formation of scum. Even milk diluted with water is added for further clarification of the juice, when the jaggery is intended for personal use at home. These are not, however, ordinarily done. Even the preliminary removal of scum is omitted, with the object of getting the maximum weight of jaggery.

2. *Evaporation of the juice.* The fire in the furnace is increased after the removal of the scum, so that the water in the juice may get evaporated quickly. There is some inversion of sucrose during boiling and if the period of boiling is increased by low heating, the inversion is increased.

3. *Concentration of the syrup.* After a large part of the water in the juice evaporates, the boiling liquid gets viscous and assumes a thin syrupy consistency. The temperature, which was previously round about 100° C. begins to rise rapidly. The heating is continued with a low fire. Even so, the sugary materials tend to get charred on coming into contact with the bottom of the pan, where the temperature is rather high. Wooden

paddles provided with long handles are now used for stirring the syrup, so that no part of it remains in contact with the pan for a long time. As the syrup thickens, its consistency is watched carefully to enable the boiling being stopped at the correct stage. If a small quantity of syrup at the correct stage of striking is poured into cold water and manipulated with the fingers, it solidifies rapidly as a thin flaky sheet, which produces a sharp metallic sound when struck against the side of the pan; a thudding sound alone is produced in the earlier stages. The syrup is rather thick and highly viscous and the temperature at which it is ready for removal ranges from 118° to 124° C., depending upon the purity of the sugar-cane juice; syrup made with juice of a high degree of purity can be taken to 124° C., while syrups made with juice of low purity get charred at this high temperature. The rise of temperature is very rapid at this stage with syrups of high purity and very slow with those of a low purity.

Cooling the syrup and moulding. The boiling pan is removed from the fire and the syrup is transferred to a shallow long wooden tray for cooling. The hot syrup is stirred constantly with the paddle to bring about uniform cooling. The syrup thickens on cooling and it is poured into suitable wooden moulds for solidification. The moulds are cut in big blocks of hard fibrous wood. The pores on the surface of the mould are sealed by wetting and spreading a thin film of water on the surface. The individual holes on the mould are truncated pyramids in shape. The pyramidal shaped jaggery goes by the name of 'cubes', whose height ranges from 1½ to 5 inches. The syrup solidifies on cooling in a few minutes, when the mould block is turned upside down

and struck with heavy wooden mallets, for dislodging the 'cubes'. These are dried and stored, or packed in gunny bags for sale. If the syrup is not concentrated sufficiently, or if the juice is not of the requisite purity, the jaggery does not set properly and the 'cubes' do not drop down readily from the mould. In such cases, the syrup is poured in pits dug in the ground and lined with cloth.

Jaggery quality. The quality of jaggery is judged by its (1) colour, (2) structure, (3) hardness and (4) taste.

1. Colour. The colour of the jaggery is derived from the colouring materials originally present in the juice and those formed when jaggery is being made. Reducing sugars decompose during boiling, combine with the amino acids in the juice and give rise to coloured products. A certain amount of colour is also produced by the caramelisation of sugars during the last stages of boiling the syrup.

The longer the period of boiling, the greater is the decomposition of sugars and calcium gluconate, and greater is the colouring material produced. When small quantities of juice are boiled, the time of boiling is reduced and this may be preferred from the point of view of the production of a light colour in the jaggery. Protracted boiling affects the colour and the keeping quality of jaggery.

Juice of high purity gives good coloured jaggery and juice of low purity gives dark coloured jaggery. Sugarcane grown in light soils produces light coloured jaggery, while that from heavy and alkaline soils produces dark coloured jaggery. Maturity of the sugarcane also has an

effect on the purity of the juice and the colour of the jaggery produced. Addition of increasing quantities of lime to the juice intensifies the colour of the jaggery progressively.

2. *Structure.* When a jaggery 'cube' is broken across, the broken surface presents a granular structure in the case of good quality jaggery. There is a light coloured hazy ring about the centre, where white glistening sugar crystals can be made out. The lightness of the colour of the ring, its size and the size of the sugar crystals determine the quality of the jaggery.

3. *Hardness.* When jaggery 'cubes' are struck against one another, a metallic sound is produced with hard types and a thudding sound with soft types. Scratching the surface of the jaggery also gives an idea of the hardness. Crystalline structure, hardness and keeping quality go together and these vary inversely with the glucose content. Light colour and keeping quality are not compatible beyond a certain limit.

4. *Taste.* Jaggery, made with sugarcane grown in alkaline soils, or with brackish irrigation water is a bit saltish to taste. When canes are damaged severely by red rot or stem borers, the jaggery produced gives a faint bitter taste.

Brown sugar. In certain regions, the concentrated syrup is rubbed with wooden paddles against the cooling tray, at the time of cooling, when a powdery jaggery is produced and this is called 'brown sugar'. The syrup is struck at a higher temperature for brown sugar than for jaggery. Brown sugar can be made only with juice of a

high degree of purity and it is very light in colour and pleasing to the eye.

Treacle. If the concentration of the sugarcane syrup is stopped when it is of the consistency of thin honey, at a temperature of about 107° C., it keeps in storage without fermenting and it is called 'treacle'. It can be used instead of honey for sweetening food preparations.

Boora sugar. White sugar, called 'boora sugar', has been made in India from very early times. It is light cream in colour and is not gritty to the feel like the crystal sugar made in factories. The sugarcane juice is boiled as for the manufacture of jaggery and the scum is removed carefully. The boiling syrup is removed from the fire at an earlier stage, when the temperature is 110° to 112° C. This concentrated syrup is called 'rab' or 'massecuite'. It is cooled and kept in earthen pots for about a week. Sucrose crystallises out during the period and glucose remains dissolved in the mother liquor. The pots are then broken and the 'rab' is transferred to large cylindrical bamboo baskets kept over sloping cement floor. The molasses draining from the basket is collected and used for making low grade jaggery. The sucrose is left in the basket. It is covered with a layer of water weeds (*Hydrilla verticillata* Royle., *Vallisnaria spiralis* L. etc.), which absorb the impurities from the top layer of sugar and bleach it. The bleached sugar is removed every morning to a depth of nearly an inch, and a layer of fresh weeds is laid over the sugar in the basket. The purified sugar is melted in water and reboiled. Dilute milk is added to the boiling liquid and the scum is removed carefully. The syrup is concentrated and finally rubbed into white sugar, as in the case of brown sugar, referred to earlier. The sugar obtained is creamy white

in colour and is largely used in sweetmeat trade, for dusting over fried foodstuffs.

Crystal sugar. Pure sugar, or sucrose is made in large factories, using complicated machinery. Sugarcane is crushed with machinery and the begasse is macerated with water repeatedly and nearly 97 per cent of the sucrose present in the sugarcane is recovered in the juice. It is clarified by the carbonation or sulphitation process, using lime and carbon dioxide, or sulphur dioxide. The scum that forms is removed and the juice is passed through filter presses. The filtered juice is concentrated in a series of vacuum pans, under reduced pressure and steam heating. The concentrated syrup is allowed to crystallise and centrifuged for separating the molasses. The sugar is then washed free of molasses by spraying small quantities of water and finally with a dilute solution of synthetic blue, which gives the sugar crystals a white colour. It is dried in hot chambers, ground and packed for sale. The recovery of sugar in factories in India ranges from 9 to 11 per cent on the weight of sugarcane. The molasses draining from the centrifuge is a brownish viscous liquid containing glucose and unextracted sucrose. A lower grade of sugar is recovered from the molasses. The sucrose in the molasses cannot be recovered completely.

Refining jaggery. White crystal sugar is also produced in factories by refining jaggery or raw sugar. The jaggery is dissolved in water, the suspended impurities are removed by filtration and it is clarified by passing it through bone char kept packed in tall chambers. The clarified juice is concentrated in vacuum pans and made into white sugar, in the same way as when sugarcane juice is processed.

Utilisation of by-products.

1. *Molasses.* It is the viscous liquid left behind after sucrose and it is separated by centrifuging sugar in factories. It is used in various ways for the production of rectified spirit, methylated spirit, power alcohol, alcoholic beverages, yeast, cattle food etc. It has been dehydrated in recent years and put in convenient form, for feeding animals. Dehydration has facilitated transport of molasses over long distances.

2. *Begasse.* It is the fibrous residue left behind, after the extraction of the juice from sugarcane. It is used chiefly as fuel for steam boilers and jaggery furnaces in India. It is used in the manufacture of low grade paper, including fibre boards like celotex, artificial silk and plastics.

3. *Molascake.* Molasses are mixed with begasse screenings and groundnut cake, and made into convenient blocks, weighing about one pound each. Mineral mixtures can also be added for improving the feeding value. These are handy and convenient for feeding animals. Cattle relish them. The percentage composition of molascake is given under :

Ingredients	With minerals	Without minerals
Moisture	9·8	10.3
Ash *	11·9	7·3
Fat	4·7	5·0
Protein	29·9	31·3
Fibre	3·7	3·8
Carbohydrates	40·0	42·5
*containing		
CaO	3·7	0·5
P_2O_5	1·8	1·1
Nutritive ratio	1 : 1·6	1 : 1·6

4. *Bego-molasses.* This consists of a mixture of equal parts of molasses and begasse screenings and has been used successfully as a feed for cattle and horses at the Indian Institute of Sugar Technology. It has twice the value of wheat *bhusa* and can be safely used when fodder is scarce.

5. *Filter press mud.* The suspended impurities in sugarcane juice are retained in the filter press in sugar factories, in a plastic condition. It has 70 to 80 per cent of moisture, up to 1 per cent of sugars and 8 to 10 per cent of finely divided fibres. On a dry basis, it has 63 to 74 per cent of organic matter, 1 to 1·5 per cent of nitrogen, 4·5 to 5 per cent of phosphoric acid and 2·5 to 7 per cent of potash. The filter press mud is available in considerable quantities in factory areas and can be used as manure. When it is applied to the land directly, there is considerable bacterial activity and the bacteria utilise the nitrogen in the soil for their growth and the crop following is starved of nitrogen, for a period temporarily. After the decomposition of the mud, the bacteria present die out and the nitrogen taken from the soil is returned to it as bacterial protein and it becomes available for the use of crops in course of time. In view of this drawback, the filter press mud can be composted and applied to the land. Composting has to be done in heaps not exceeding 5 feet in height and it takes 7 months for composting.

6. *Sugarcane trash.* Dry sugarcane leaves produced are a fifth of the weight of sugarcane. They are used as fuel for jaggery furnaces and what is left behind is burnt in the field. It is a bulky product and takes a long time to decompose. It can be moistened with a suspension of pig's dung in water and kept heaped up for decomposi-

tion to take place. The special bacterial flora in the pig's dung assist greatly in hastening decomposition. Addition of nitrogenous compounds like ammonium sulphate provides nitrogen required by the bacteria, which bring about and accelerate decomposition.

Yield. The standard yield of sugarcane and of jaggery varies from tract to tract and the following are the yields in some of the important districts in South India :

Name of district	Yield of sugarcane in tons per acre, or of jaggery in pothies of 250 lb.
Visakhapatnam	23·5
East Godavari	33·8
Chittoor	35·4
South Arcot	29·4
North Arcot	24·2
Coimbatore	35·0
Tiruchirapalli	24·6
Madurai	26·2

Source : *Season and Crop Report of the Madras State for the year 1952—'53*, 1955. The yield of jaggery is based on the results of crop cutting experiments conducted from 1936 to 1940.

The yield of the sugarcane crop is reckoned in terms of jaggery per acre. The same figure also denotes the yield of millable canes in tons per acre. One ton of sugarcane produces about a *pothy* (250 lb.) of jaggery on the average. The percentage of jaggery to sugarcane ranges from 11 to 13 and to sugarcane juice 16 to 18.

CHAPTER XI

CONDIMENTS AND SPICES

XI. 1. Turmeric (*Curcuma longa* Linn.)

Vernacular names: Tamil - manjal; Malayalam - manjal; Telugu - pasappu; Kannada - arashina; Hindi - haldi.

Importance. Turmeric is one of the important commercial crops in South India. It is cultivated for the production of rhizomes, which develop in clusters at the base of the plant. The central rhizome or 'corm' is round or elongated, called 'rounds', with a number of roughly cylindrical rhizomes springing from its side, which go by the name of 'fingers'. Both the raw and the dried rhizomes go by the name of turmeric. It is used as a condiment and a cosmetic in Asiatic countries and as raw produce in the manufacture of certain yellow dyes. India featured as the main exporting country in 1953 and contributed 109,000 cwts. of dry rhizomes to world trade.

Distribution. Turmeric is cultivated all over India and South-East Asiatic countries like China, Indo-China and East Indies. The normal extent of its cultivation in the important areas in Madras and Andhra States is as in the next page.

Turmeric is cultivated in large areas as a rainfed crop in Malabar and as an irrigated crop, chiefly in Coimbatore, Tiruchirapalli, Guntur, Cuddapah, Krishna and Godavari districts. Even in these districts, the

Madras		Andhra	
District	Extent in acres	District	Extent in acres
Salem	1,030	East Godavari	3,110
Coimbatore	4,360	West Godavari	3,310
Tiruchirapalli	2,100	Krishna	4,680
Malabar	6,060	Guntur	9,920
Others	4,060	Cuddapah	5,720
		Others	2,460
Total (Madras)	17,610	Total (Andhra)	29,200

cultivation of the crop is confined to certain taluks only, where the soil conditions and irrigation facilities are suitable. The cultivation of the crop, the processing and marketing of the produce have become specialised in these areas. The crop is cultivated in small areas of 50 cents to an acre in individual holdings, in general. It is only in Guntur that rich farmers have each 10 to 20 acres under the crop. At the other end are the back yards of Malabar, where the cultivation is limited to a few cents and the crop is grown for home use and local consumption.

Adaptation. Turmeric is essentially a crop of the humid tropics, though it is cultivated to an extent in the subtropical regions also. It thrives in moist shady situations, but not where water stagnates, and it can be cultivated as a rain fed crop in regions of heavy rainfall like the Malabar coast. It comes up in regions of mode-

rate rainfall, only under irrigation. It is cultivated in South India chiefly in wet lands and to a limited extent in garden lands, where it is not so remunerative. It is an exhausting crop, which requires heavy manuring.

Soils. Red loamy soils, which are rich in organic matter, favour the development of rhizomes and they are ideal for the cultivation of turmeric. But it is cultivated in a variety of soils, as in the black clay loams of Guntur and Krishna districts, the heavy black soils of Karur in Tiruchirapalli district and the poor red lateritic loams of Malabar.

Rotations and mixtures. Turmeric is cultivated in high level wet lands once in 3 or 4 years and the other crops which are grown during the intervening periods are rice, sugarcane, banana and root crops. These do not come in any regular sequence. No two fields have the same sequence of crops.

There are no regular rotations in garden lands either. Turmeric comes on the land once in 2 to 5 years, depending upon the size of the holding and oftener in small than in large holdings. The other crops that are grown on the land are redgram, maize, groundnut, gingelly, *ragi*, *cumbu* and *tenai* in Andhra Desa and fodder sorghum, *cumbu*, *ragi* and Cambodia cotton in Tamil Nad.

Turmeric is cultivated as a pure crop ordinarily, as the yields are reduced when other crops are mixed with it. But, castor seeds are dibbled sparsely here and there for providing some light shade and protection against the sun for the turmeric plants. Some vegetables may be planted along the borders for meeting the household requirements. In Tiruchirapalli and Coimbatore districts,

there is the practice of interplanting *cumbu*, *ragi* and maize, or vegetables like onion, chilli, brinjal and colocasia, and taking a subsidiary crop during the early stages of growth of turmeric. These give a small income, which is a stand-by for the poor peasants, who cannot afford to wait till the long duration turmeric comes to harvest 7 to 8 months after planting.

Cultivation. The land is prepared in various ways in the different regions. The number of times the land is ploughed is as low as 2 in the Mydukur region and as high as 16 in the Rajampet area, both in the Cuddapah district; the average is 6 to 8 times in most turmeric regions. Ploughing is commenced immediately after the harvest of the previous crop when there is moisture in the soil, or after the soil is moistened by rain and the land is in condition for ploughing. Manure is applied to the land before the last ploughing.

Manurial practices are even more variable than preparatory cultivation. Manuring is done more heavily than for most other crops as a routine practice, particularly with the locally available organic manures. Light soils are manured more heavily than heavy soils. The following illustrates the variations prevailing in the different regions :

1. Clay and silt are applied at 100 to 300 cart-loads to an acre in the garden lands of Guntur and Krishna districts. Tank and channel silt are preferred, if available nearby, to clay scraped from the surface of wet lands.

2. Cattle manure is applied at 20 to 50 cart-loads per acre, depending upon its availability. Turmeric is planted in small pits in Malabar and dry powdered cattle

manure is applied at one double handful to each pit, before planting.

3. Cattle are penned in the field during the summer months, at 800 to 1,000 cattle for a night per acre, in Krishna and Guntur districts. The practice of keeping cattle in the open fields during the summer nights is a common feature in these districts. The cattle are more comfortable in the fields than in stalls, when the summer is very hot.

4. Sheep are penned at 2,000 to 4,000 sheep-nights per acre extensively in turmeric regions, to supplement the cattle manure applied.

5. Green manure crops are raised in areas where manure is in short supply and where the rainfall and the cropping permit green manure crops being raised during the preceding fallow period. Sunhemp is usually sown for the purpose in Coimbatore district and greengram in Repalli taluk of the Guntur district. Turmeric farmers give the green manures a value equal to that of 15 cart-loads of cattle manure per acre.

6. Green leaves are regularly used for mulching turmeric fields in Malabar, once at the time of planting the crop and twice later at intervals of 10 weeks, and partially covered by earthing up. The twigs that do not decompose are removed at the time of the next mulching. In Cuddapah, green leaves are spread over the land at 20 cart-loads to an acre, after planting the crop.

7. Organic refuse like groundnut husk, useless palmyra leaves from old dismantled roofs, *cumbu* straw not suitable for use as fodder, composts etc., are applied to heavy soils in Tamil Nad.

The bulky organic manures are supplemented in certain cases with 4 to 8 bags of groundnut cake, 5 to 10 bags of castor cake, or 2 to 3 cwts. of ammonium sulphate per acre. These are broadcasted over the field at the time of the first weeding and covered by ploughing in between the turmeric rows, or by hand hoeing. These are also applied along the rows or near the base of individual plants.

Planting. Selected rhizomes obtained from the previous season's crop are kept in storage during the summer months and used as the seed material for propagation. Healthy crop areas are sometimes set apart for seed in Tamil Nad and the rhizomes are dug one month after the main harvest, when the plants are fully dry. Such rhizomes do not have surplus moisture and keep well in storage. Healthy and mature rhizomes are stored in heaps, over sand in cool places, either under trees, or in house verandahs, covered with dry leaves. The heaps are sometimes plastered over with paste made with clay and cow dung. The rhizomes are spread out after 2 months of storage and rotten ones are removed by careful peasants. When there are no rains during summer, water is occasionally sprinkled over the heaps kept under trees.

The central corms alone are used for planting in Krishna and Guntur districts, and 'fingers' alone are planted in Cuddapah district. Both 'rounds' and 'fingers' are planted in Tamil Nad, but separately in the field and not mixed together. As the 'rounds' sell at prices higher than the 'fingers' in general, the latter may advantageously be used for planting. The 'rounds' are split longitudinally into 2 halves and the 'fingers' are broken

into pieces of about 2 inches in length for planting. The rhizomes put out sprouts during storage and they are split or broken for planting with at least one sprout or prominent bud ready to sprout in each piece.

Turmeric is planted usually in May—June in wet lands almost throughout Tamil Nad, depending upon the time of supply of water in the irrigation system. Planting is done in garden lands in the month of May itself. In Malabar, planting is done by the middle of May with pre-monsoon showers. The planting is done in June at Cuddapah, in July at Guntur and in August at Krishna. Thus the planting of turmeric is limited to the period from May to August.

Turmeric is planted in various ways in the different regions. In Malabar, raised beds, 3 feet wide and 15 to 20 feet long are formed, with drainage channels in between. Small pits are dug on the beds 9 inches apart either way, filled with dry powdered cattle manure and soil, and the rhizomes are planted at one piece per pit. The beds are raised to facilitate rain water being drained easily. This system is not followed in other regions, where the rainfall is only moderate. Both bed and ridge planting are in vogue in Tamil Nad. The rhizomes are planted 8 to 10 inches apart either way, in 8 to 10 feet square beds. The ridges are 1½ to 2 feet apart in loamy soils and the rhizomes are planted on the crests of ridges 10 inches apart. The ridges are 2 to 2½ feet apart in clayey soils and planting is done on both the sides. Shallow cuts are made in the soil with spade and when they are being removed from the soil, a rhizome is slipped into each cut by a second labourer. The soil sliding down into the cut covers the rhizomes automatically. Some-

times the rhizomes are scattered in the field and pressed into the soil with the hand. The quantity of rhizomes planted in an acre ranges from 1,400 to 1,800 lb.

The rhizomes are dropped in plough furrows in Andhra Desa and covered by the soil when the adjacent furrows are opened. The spacing given in Guntur and Krishna districts is 18 inches between rows and 9 inches between plants in the rows, and 12 inches and 6 inches respectively in Cuddapah district. Ridges and furrows are formed with wooden ploughs at the time of planting in Guntur and Krishna districts and rectified later by interploughing at the time of weeding. In Cuddapah, the land is levelled with a levelling board after covering the rhizomes by ploughing and beds, 6 feet by 10 feet, are formed, marking the bunds with wooden ploughs. A few rhizomes are exposed at the time and these are pressed into the soil, when the beds are rectified. The quantity of rhizomes planted is 2,000 lb. per acre in Guntur and Krishna districts and 2,500 lb. in Cuddapah district.

After - cultivation. Turmeric sprouts appear above the ground in 10 to 20 days and stray sprouts may emerge up to 4 weeks from planting. The crop is hand hoed and weeded 2 to 4 times at intervals of 4 to 6 weeks, the first hoeing being done about a month after planting. When subsidiary crops are grown along with turmeric, the crop is hoed with spades twice in Tamil Nad, after the harvest of the former, with an intervel of a month. The line sown crops in Guntur and Krishna districts are inter-ploughed 4 times and ridged up finally with wooden ploughs.

Irrigation. Major turmeric areas are under flow irrigation from river and tank systems. Water is also

lifted with swing baskets for irrigating high level wet lands. The number of irrigations given varies with the type of soil; 15 to 20 irrigations are given for clayey soils and about 40 for sandy loams. The cost of lifting water from wells increases the cost of cultivation in garden lands, which is not so profitable as in the case of wet lands.

Harvest. The crop gets ready for harvest when the leaves start drying, 7 to 8 months after planting. It is harvested in January to March in Tamil Nad and in February to April in Andhra Desa, where the planting itself is later. The stems and leaves are cut and used for covering seed rhizome heaps and as fuel. The rhizomes are dug with spades in Tamil Nad. In Andhra Desa, ploughs are worked carefully by the side of turmeric rows so that the rhizomes are laid aside and left partially exposed. They are then gathered easily. The rhizomes are cleaned of the adhering earth and roots, and the 'fingers' and mother corms are separated. Earth does not stick fast to the mature rhizomes, if the moisture in the soil is at the correct level at the time of harvest. Fresh rhizomes from each plant weigh 1½ to 3 lb., on the average, though it may go up to 6 lb. with vigorous individual plants. The average number of 'fingers' produced is 8 to 12 per plant and vigorous plants may produce up to 40 'fingers' each.

Curing rhizomes. Fresh rhizomes are used as a cosmetic by women to a small extent during the season and some are kept in storage for use as seed material later. The rest of the produce is boiled and dried for the market. Rectangular iron pans, 3 ft. x 2 ft. x 1½ ft., are used for boiling turmeric rhizomes in Tamil Nad. The pan holds

150 lb. of rhizomes. A dilute suspension of cow dung in water is added to it, till the rhizomes are nearly immersed. They are covered with a gunny piece and boiled for an hour, when the liquid froths up and emits white fumes with the characteristic smell of cooked turmeric. The cooked rhizomes are soft and yield on being pressed between the fingers. The pans are then removed from the fire, the water is drained and the rhizomes are spread out on the floor for drying in the sun. They get dry in 10 to 15 days. The stage at which cooking is stopped has a large influence on the colour and aroma of cured turmeric and trained men are employed for curing.

In Andhra Desa, the pan used is 5 feet square and 2½ feet high and it is permanently fixed over the furnace, which has an inlet for feeding fuel and an outlet for smoke to get out. Four immersion troughs, 2 feet cube, made with perforated iron sheets and provided with looped handles at the top, are placed inside the boiling pan, and they are filled with raw rhizomes. Each trough holds one gunny bag (168 lb.) of rhizomes. The pan is filled with water till the rhizomes are immersed, covered with lid and boiling is commenced. There is frothing inside the pan after an hour's boiling and white fumes come out from under the lid. The troughs are then removed from the pan and the cooked rhizomes are spread out for drying. The troughs are placed again inside the pan and a fresh charge is commenced, after making up the water lost by evaporation during the previous charge. Ten charges are boiled in a day, working for 12 hours and an acre's produce can be boiled in 2 days. The work is continued through day and night, without any break during the peak harvest

period. This furnace saves time and fuel and is more efficient than the one used in Tamil Nad. The water in the boiling pan is not changed and the heat required for bringing the water to boiling each time is saved. Since the pan is fixed, the heat in the furnace is conserved and not dissipated as in the other.

Processing the produce. Most roots and scales on the rhizomes drop off during drying, and those that remain have to be removed. Bamboo baskets, kept suspended at a height of 3½ feet from the ground with tripods, are partially filled with dry rhizomes and broken granite stone pieces, and rocked to and fro. The roots and scales are shed and the rhizomes take a polish. This is the method in use in Tamil Nad. Hand rotated drums made with diamond mesh expanded iron are also used to a small extent. Turmeric is polished finally with machinery at Erode, the chief turmeric assembling market, before it is distributed to the various consuming centres.

In Andhra Desa, the dry unpolished turmeric is sent to the assembling market centres, where polishing is done in rotary drums operated with power. The polishing is adjusted to the demand of the different consuming centres. Duggirala and Tenali in Guntur district, and Cuddapah and Koduru in Cuddapah district are the assembling markets in Andhra Desa.

When turmeric is to be coloured, it is polished only slightly, as colour does not stick to thoroughly polished surfaces. A suspension of turmeric powder in water is sprinkled over rhizomes kept in baskets and shaken for distributing the colour evenly at Erode. Artificial colours like 'middle chrome' are used dry or in solution,

for colouring the rhizomes at Cuddapah. Wet colouring gives a brightness to the product, after it is dried in shade.

Yield. The yield of raw rhizomes ranges from 20,000 to 26,000 lb. per acre. A fourth of this is reserved for seed and the rest is cured and 4,000 to 5,000 lb. of dry turmeric is obtained. The ratio of cured to raw turmeric is 1 : 4. A fourth of the produce is made up of mother corms, which are kept in storage for planting in Andhra Desa. They lose 50 per cent of their weight during the summer months. Thus, the corms' weight at the time of planting is one-eighth of the weight of the raw produce. It is sufficient for planting an area equal to 1 to 1·25 times the original area.

Marketing. Turmeric, produced in the minor turmeric areas, is absorbed by the local markets. A large part of the turmeric produced in the major areas is sent to Erode and Duggirala, which are important turmeric marketing centres. It is distributed from these centres to the various consuming markets, both inside and outside India. Koduru and Cuddapah are the market centres which handle the produce of the Cuddapah district. Turmeric is also powdered at Koduru and distributed to the consuming centres in Tamil Nad, chiefly Madras, Madurai, Tiruchirapalli and Erode.

Storage. Cured turmeric is subject to weevil damage and it is, therefore, kept in storage in underground pits. These are 15 ft. x 10 ft. x 7 ft. in size at Guntur and Krishna districts and hold 200 bags of rhizomes. The pits are lined with thick twists of *rellu* grass (*Saccharum spontaneum* Linn.) and a layer of date palm mats inside, before filling it with cured rhizomes. The same

materials are used for covering the turmeric at the top of the pit also, and a thick protective layer of soil is laid finally. The pits are lined in other tracts with materials available locally.

XI. 2. Chilli or red pepper (*Capsicum annuum* Linn.)

Vernacular names: Tamil - milagai; Malayalam - milagu; Telugu - mirapakaya; Kannada - menisinikayi; Hindi - mirch.

Importance. Chilli is an introduction of recent times, when compared to other crops. It has, however, become a very popular and favourite condiment, which is in every day use in India, more particularly in the south. It is rather peculiar that it is in liberal culinary use in tropical South India, Africa and America, where the crop develops a greater pungency than in warm and cold regions. It is a fair source of vitamins A, B and C, both in the green and dry state. It is a chief commercial crop in the dry land tracts of Guntur and Godavari districts and in the garden land regions of south Tamil Nad from Tiruchirapalli to Tirunelveli districts.

Adaptation. Chilli is essentially a crop of the tropics and comes up well in the hot regions of South India. It flourishes when there are light rains in the early stages and moderate rains during the period of active growth. Prolonged dry weather favours the incidence of thrips, which colonise on the tender leaves and bring about their curling. Sharp showers of rain wash out the thrips, reduce the severity of the damage and enable the plants to make fresh growth. Rains during the period of flowering and the development of young fruits promote the shedding of the flowers and

young fruits. Later rains induce fungoid diseases like 'fruit rot', which causes the rotting of the fruits and their spoilage.

Chilli is in the field for 5 to 7 months and can be grown purely under rainfed conditions, only when the seasonal rains are distributed over a long period, or where the soil is highly retentive of moisture, like the black cotton soils of Guntur. It is grown as a dry crop in regions which have a rainfall of 30 to 45 inches. Lower rainfall is insufficient and higher rainfall is not tolerated by the crop. Where the rainfall is less than 30 inches, the crop can be grown under irrigation successfully. In fact, large areas of chilli are under irrigation in Madras. It is grown mostly on the plains, but can be grown in places having an altitude up to 4,000 feet above sea level. As the elevation increases and the prevailing temperature gets lowered, the fruits get less pungent.

Chilli comes up best in well - drained deep clay loams, as at Guntur. Though it is the ideal soil, chilli can be grown in loamy and sandy soils with adequate manuring and irrigation. Drainage is essential and the crop is stunted even when there is a little stagnation of water.

Distribution. Chilli is under cultivation in large areas in all Asiatic countries, Africa, South and Central America, parts of U. S. A. and southern Europe, both under tropical and subtropical conditions. The extent of its cultivation is rather limited in the subtropical regions. It is cultivated throughout India, and extensively in Peninsular India. In world trade, India was the second largest exporter with 156,000 cwts. of chilli during the year 1953, coming after Mexico, which exported 211,000 cwts.

The extent of chilli cultivation, district-wise, under irrigated and rainfed conditions in Madras and Andhra States during the year 1952—'53 is furnished below.

Madras had 1·19 lakhs acres under chilli, of which 82,767 acres were under irrigation, representing 70 per cent of the total area under the crop. Andhra had 1·66 lakhs acres of chilli, of which 47,663 acres were under irrigation, representing 29 per cent of the total area. Irrigated crops are prominent in Madras, particularly in Tirunelveli, Tiruchirapalli, Madurai, Coimbatore and Ramanathapuram districts. On the other hand, rainfed crop is predominant in Andhra, particularly in Guntur, Kurnool and East Godavari districts. Guntur is an important centre, where the soil and climate favour the

Madras			Andhra		
Name of district	Irrigated	Rain fed	Name of district	Irrigated	Rain fed
	acres	acres		acres	acres
Chingleput	3,441	742	Srikakulam	5,121	954
South Arcot	2,953	14	Visakhapatnam	1,958	3,074
North Arcot	4,826	291	East Godavari	2,082	17,323
Salem	7,507	502	West Godavari	1,265	9,877
Coimbatore	8,563	—	Krishna	6,772	4,189
Tiruchirapalli	9,976	10,897	Guntur	708	50,111
Tanjore	4,516	618	Kurnool	7,102	27,446
Madurai	9,613	42	Anantapur	8,552	1,532
Ramanathapuram	7,749	7,946	Cuddapah	4,633	117
Tirunelveli	23,623	55	Nellore	6,510	2,723
Malabar		6,631	Chittoor	2,960	1,256
South Kanara		8,369			
Nilgiris		119			
Total (Madras)	82,767	36,226	Total (Andhra)	47,663	118,602

Source: Madras Government, *Season and Crop Report of the Madras State for the year 1952—'53*, 1955.

cultivation of chilli under rainfed conditions. They also favour the cultivation of other profitable commercial crops like tobacco, cotton and groundnut.

Varieties. Chilli is classified into varieties, based on the shape, size, colour and pungency of the fruits. The fruit may be very small, ½ to ¾ inch long and 1/10ths of an inch across, or be as big as an orange. Both the big and the small varieties are not under general cultivation. The former are extremely pungent, and the latter are almost devoid of pungency and grown for use as vegetable as in parts of Tanjore. The mature chilli fruit may be white, blue, black, yellow or red, the last being the most common colour. The fruits are of different shapes. Some are rounded and bulbous. Some are of medium thickness and long, with bent tips. Some are shaped like elephant tusks.

Rotations. In Guntur, two rotations covering a period of 3 and 4 years are in vogue, namely (1) tobacco or fodder sorghum in the first year, chilli in the second year, followed by groundnut, maize or cold weather sorghum in the next year and (2) a grain crop *variga* (*panivaragu*), *sajja* (*cumbu*) or sorghum in the first year, chilli in the second year and tobacco in the third year, followed by groundnut in the fourth year. In the Godavari *lankas*, *budama* rice is followed by chilli in the second year and by tobacco in the third year. In the uplands of the Central Godavari area, sunhemp is cultivated early and chilli late in the season. Chilli is commonly cultivated as a pure crop and rarely mixed with cotton and onions in the Gollaprol area in East Godavari.

In Tamil Nad, chilli is grown in garden lands in rotation with *ragi*, Cambodia cotton, summer groundnut

and other crops. It is grown on the same land without any rotation in parts of Ramanathapuram, as at Mudukulathur and Paramakudi. It is ordinarily grown as a pure crop, though onion may be planted sparsely along with it sometimes. In dry lands, groundnut, chilli and a cereal form a common sequence.

Season. The rain fed crops are ordinarily transplanted in September-October and nurseries are sown 6 weeks in advance of the anticipated time of planting. The crops are uprooted in March-April. The season for planting the irrigated crop is May to July. The earlier plantings are often subject to attack by thrips, while later plantings are free, comparatively.

Preparatory cultivation. The land is ploughed a number of times and brought to good tilth. It is finally laid into beds with irrigation channels in between, or ridges and furrows for planting chilli in garden lands. This is not necessary in dry lands, where transplantation is done only after the receipt of good soaking rains.

In the Godavari region, the land is ploughed after the summer rains and left undisturbed for weathering till September, when the crop is transplanted.

In Guntur, the land is ploughed with the commencement of the south-west monsoon rains and the furrows are opened 9 to 12 inches apart. Furrows are opened at the next ploughing in the inter-furrow spaces of the previous ploughing. This method of ploughing by splitting the inter-furrow spaces is continued in the subsequent ploughings also. The furrows are close to one another at the final ploughing given at the time of planting the crop.

Manuring. The chilli crop requires heavy manuring and cattle manure is applied at 20 to 40 cart-loads to an

acre, as a basal dressing. Alternatively 2 to 4 thousand sheep are penned. It is considered by farmers that sheep manure gives a bright colour to the chilli fruits. Cattle manure, sheep dung and bat guano are sometimes applied after transplanting the crop, as a top dressing to supplement the manure applied initially. The application of groundnut cake and ammonium sulphate to chilli, particularly the latter, 1½ months after planting, has become a common practice in recent years. The cake is applied at 300 to 500 lb. to an acre and the sulphate at 150 to 200 lb. Manures are applied in large quantities, particularly when chilli sells at high prices.

Nursery. Young chilli plants are very delicate. They are, therefore, raised in nurseries and the seedlings are later planted out in the field. Seeds are sown directly in the field, only in parts of Cuddapah, Guntur and Ramanathapuram. At Cuddapah, the seeds are kept wet with moist cloth for 3 days, mixed with sand at the time and drilled 10 inches apart, with 5 to 6 lb. of seed to an acre. Dry seeds are drilled at 8 to 10 lb. per acre at Guntur. The plants are stunted in the early stages, but get vigorous after a time. Elsewhere, chilli seedlings, about 6 weeks old, are transplanted in the field, both under rainfed and irrigated conditions. High level lands near irrigation sources are selected as nursery areas for facilitating drainage during rainy weather and irrigation when necessary. At Guntur, the seed-beds are 4 feet wide and fairly long, even up to 20 to 30 yards. The seeds are sown at 3 to 4 lb. per cent of nursery and covered by working with wooden rakes, called *kanki danties*. The beds are watered with rose cans daily for about a week, till the seeds germinate. The nurseries are sown in July-August and there may be no need for

supplementary irrigation, ordinarily. Pot watering is done when necessary.

The nurseries are weeded 2 or 3 times and the seedlings are topped a week before planting. This induces branching and a certain sturdiness in the young seedlings. The chilli plant is susceptible to the attack of thrips, which are clustered about the tender shoots at the top and clipping the tops is an attempt to reduce the population of thrips in the field. The nursery is irrigated the day before pulling out the seedlings. It softens the soil and enables the seedlings being lifted without much damage to the root system. The seedlings are pulled out only to the extent that can be planted the same day, so that they may be fresh at the time of planting and establish readily. One cent of nursery supplies seedlings for planting an acre.

At Guntur, the nurseries are concentrated in places, where there are facilities for irrigation and the seedlings are even taken to distant places for transplanting.

In Tamil Nad, the seed-beds are prepared as for *ragi* and chilli seeds are sown at one Madras measure (2 lb.) per cent of land and one cent of nursery supplies seedlings for planting 2 to 3 acres.

Transplantation. Chilli seedlings are lifted when they are about 6 weeks old and 3 to 8 seedlings are planted in a bunch in each hole in Andhra Desa and single seedlings alone are transplanted in Tamil Nad. The planting is done in dry lands in the former, where the chances of establishment under rainfed conditions are not quite certain, and in garden land in the latter. These account for the differences in the method of planting and the seed rates used. The spacing given between plants is 1½ ft. x

1½ ft. in Godavari, 2 ft. x 2 to 2½ ft. in Guntur and 2½ ft. x 1½ to 2 ft. in Tamil Nad. The planting is done in beds in garden lands.

In Andhra Desa, lines are marked 1½ to 2 feet apart, both along and across the field, with ploughs. Seedlings are transplanted at the intersections of these 2 sets of furrows. This is called 'check planting'. One person carries the seedlings and drops 3 to 8 seedlings at each junction, where the furrows cross one another. Another person following makes a small hole at the junctions by pressing a round peg, about 2 inches in diameter, into the soil. A third one fills the holes with water carried in pots, at one glassful to a hole. The last person transplants the seedlings in the holes and presses the soil about the roots of the transplanted seedlings. Pot watering is done to the plants till they get established properly. Gaps caused by the failure of seedlings are filled up with fresh ones.

After-cultivation. The chilli crop is not intercultivated in the Godavari region. In Guntur, blade harrows are worked both along and across the field, once or twice. In addition, the inter-row spaces are sometimes worked with ploughs. In Tamil Nad, the crop is hand hoed 2 or 3 times and finally hoed deep with spades and the plants are earthed-up at the time. Where seedlings are planted on ridges, the interspaces can be worked with Junior Hoe and the plants ridged up finally.

Irrigation. The crop is irrigated once in 7 to 10 days in garden lands, except during rainy weather. Lighter soils require irrigation more frequently. The crop is given 16 to 20 irrigations at Coimbatore, in general. Irrigation increases the cost of cultivation considerably, but the larger yields obtained make up.

Harvest. The chilli seedlings start flowering in the nursery itself at Guntur, when they are 6 weeks old and they are then transplanted. The crop flowers in the field during rainy weather, one month after transplantation and these flowers are shed. Flowers formed later, after the close of the north-east monsoon set and develop into fruits. The picking of ripe fruits commences in January. Fruits which have changed colour and ripened alone are picked. They are red or yellow in colour, depending upon the variety. Three pickings are done in dry land areas, once a month and the final picking is towards the end of April. In garden lands, pickings commence 3 months after planting. The fruits are picked at intervals of 8 to 10 days, during the period of peak production. There are 8 to 10 pickings on the whole, spread over 3 to 4 months. The crops are pulled out afterwards, that is, 6 to 7 months after planting.

The ripe fruits are spread out on mats or on clean ground exposed to the sun and gathered after they get dry. The dry fruits are bulked in the morning, when they are pliable, to prevent the pods from cracking and shedding the seeds while handling and packing. The fruit stalks get detached from the fruits easily during handling in certain varieties and these are not preferred. The stalks in other varieties also get detached, when there are light drizzles of rain during drying. The fruits are packed in large sized gunny bags, called *borahs*, or in large palmyra fibre baskets. A large part of the chilli produced is consumed in India itself and export to countries like Ceylon, Malaya, Aden etc., is variable and limited.

Yield. The yield of dry fruits ranges from 500 to 750 lb. per acre in dry lands and 1,500 to 2,000 lb. in

garden lands. The dry fruits are 28 to 30 per cent of the weight of fresh ripe fruits. One measure of dry fruit weighs ½ to ¾ lb., depending upon the variety.

Ripe and dry chillies, as well as green chillies are in daily use in South Indian homes. Chilli is grown throughout the year in small areas for the production of green chilli. The yield of green chilli from out of season crops is low, but green fruits fetch good prices and the net return may be even more than from season crops.

XI. 3. Ginger (*Zingiber officianalis* Rosc.)

Vernacular names: Tamil - inji; Malayalam - inchi; Telugu - allum; Kannada - halsisunti; Hindi - adrak.

Adaptation. Ginger is essentially a crop of the humid tropics and is cultivated as a rainfed crop in regions of heavy rainfall, as in Malabar and South Kanara. It is grown in the Nilgiris also to a small extent. It requires light shade and plenty of moisture. It can be grown as an irrigated crop under conditions of moderate rainfall. Thus, it is grown in small areas in Tanjore and Godavari districts, for the production of green ginger for pickling.

Heavy lateritic loams, which are free of gravel are preferred for the cultivation of ginger. It is also grown in sandy loams in parts of South Kanara. Elsewhere, it comes up in clayey soils, which have adequate drainage facilities. Soils in which turmeric can be grown successfully, can be cultivated with ginger also, by providing some shade.

Distribution. Ginger is cultivated in fair areas in Madras, Bombay and Bihar, in the plains as well as in high altitudes up to 5,000 feet above sea level as in the

Himalayan slopes. India contributed 54,000 cwts., out of a total of 133,000 cwts. of dry ginger to world trade during the year 1953. The main areas under ginger cultivation in South India are the following:

Name of district	Extent in acres (Normal)	Annual production of dry ginger in cwts. (Normal)
Malabar	10,340	66,600
South Kanara	1,050	7,400
Nilgiris	130	1,000
Madurai	100	600

Rotation. Ginger is cultivated in West Coast districts on high lands, where it is included as a regular crop once in 3 years. The following is one of the common rotations adopted in Malabar:

> Ginger in the first year, from May to December, *modan* rice in the second year from May to August and gingelly in the same year as a second crop from September to December and
>
> *samai* in the third year, from September to December. The land is kept fallow after *samai* and prepared for the ginger crop of the next year.

Ginger is sometimes grown mixed with turmeric, which makes rapid growth in the early stages and provides some shade for the more delicate ginger plants.

Cultivation. In Malabar, the land is brought to good granular tilth by ploughing repeatedly, and laid into raised beds, with drains all round, for taking off the heavy rains from the land. The size of the beds formed is

dependent on the slope of the land. Narrow beds are formed in steep slopes, while wider beds are formed in moderate slopes. Shallow pits are scooped on the beds, one foot apart each way and manured individually with a handful of cattle manure. About 15 cart-loads of manure are required for an acre. Ginger rhizomes are broken into small pieces with at least one sprouted bud in each and one piece is planted in each pit. The planting is done on receipt of pre-monsoon showers in the month of May. The quantity of ginger planted ranges from 700 to 1,200 lb. per acre, depending upon the size of the seed pieces. The beds are covered with a layer of green leaves after planting to serve as a mulch, for protecting the soil and preventing it from being washed out by the heavy rains. The leaves serve as green leaf manure. Ginger sprouts appear in about a fortnight and germination is completed in about 3 weeks. Any water collecting on the surface of the soil is drained by forming small water-ways, as otherwise the ginger rhizomes which are planted rot inside the soil.

The ginger beds are mulched with green leaves twice or thrice later, at intervals of about a month, after removing the undecomposed twigs of the previous mulch. Weeding is also done thoroughly at the time of applying the leaves.

The crop gets ready for harvest in about 7 months, by about December. The leaves wilt at the time. The dry twigs on the surface are removed and the ginger rhizomes are lifted with spade and digging fork, and cleaned free of the adhering soil and roots, as in turmeric. The yield of green ginger ranges from 7 to 9 thousand pounds to an acre.

Curing. The epidermal layer of ginger rhizomes forming the skin is removed by scraping with split bamboos, sharpened on a side to a knife point. The rhizomes are washed in water and dried in the sun for 7 or 8 days. The dry ginger obtained is dull coloured and unattractive and there is not a ready market for this crude product. The dry ginger is 25 to 30 per cent of the weight of the raw rhizomes.

Dry ginger for export is produced more carefully. It is white and free of specks. The raw rhizomes are cleaned properly and bleached before drying. They are first soaked in water and the skin is removed by scrapping with bamboo pieces. Steel knives stain the produce and are not suitable. The cleaned rhizomes are then steeped in water for a day and later for a time in thin milk of lime, of the consistency used for white washing. The material is then dried thoroughly in the sun for 8 to 10 days, turning it occasionally, to facilitate uniform drying. The dry ginger is rubbed with gunny pieces, for removing pieces of skin that may be adhering and giving it a smooth finish. If the dry ginger is not white enough, it is soaked in lime water for a time and redried. When a completely bleached product is required, the raw rhizomes which have been treated with lime water are placed in bamboo trays and exposed to sulphur dioxide fumes for about 12 hours, before drying them in the sun. Sulphur dioxide is produced by burning sulphur in rooms specially built for the purpose. The ginger bleached in this way is quite white and attractive in appearance. If the dry ginger is not sufficiently white, it is treated with lime water again, exposed to sulphur dioxide for about 6 hours and dried again. The bleaching can be done a

third time also, if necessary. The dry ginger is finally graded according to colour and size, and got ready for the market.

Preservation of seed rhizomes. The ginger crop is harvested in December and the rhizomes are kept preserved in a condition suitable for planting in the month of May. Robust and healthy rhizomes are selected at the time of harvest, for use as seed for the next season. Pits are dug in shady places or in open verandahs and a layer of sand or rice husk is spread at the bottom. The pits are filled with rhizomes nearly to the top, covered with planks and sealed with a wet mud plaster. The rhizomes keep in good condition till the sowing season in May, with the buds on them sprouting, during the period of storage.

Ginger is a condiment, powerful stimulant, antipyretic and carminative, and it is largely used in medicines. It derives its aroma from the constituent oil and its pungency from the resins dissolved in the oil. It is used as green, candied, crystallised or dry ginger.

Mango ginger (*Curcuma amada* Roxb.) The name of mango ginger given to this crop is a misnomer, as it is neither a mango nor a ginger. It is only a species of turmeric. The rhizomes resemble those of ginger and have also mango-like fragrance But it has no pungency like ginger. It is cultivated like turmeric, in small areas in parts of Visakhapatnam, Tanjore and Malabar districts. The crop has a duration of 4 to 5 months. The rhizomes are lifted in stages, as and when there is demand, and sold in a fresh state for being made into pickles.

XI. 4. Onion (*Allium cepa* Linn.)

Vernacular names: Tamil - Vengayam and erulli; Malayalam - chuvanna ulli; Telugu - ulli gadda; Kannada- erulli; Hindi - piyaaz.

The onion crop is cultivated for the production of bulbs, which develop at the base of the plant under the ground. The bulb has a basal plate, from which the roots grow on the under side. The plate is the modified stem and leaves spring up from the upper surface. The leaves get swollen and thick and form concentric layers of scales, which constitute the onion bulb. The bud in the centre develops and puts out tubular leaves and finally the flower head. The bulbs and the tender flower stalks are used as vegetable and condiment, and they blend well with most vegetables and give a characteristic flavour and taste. The bulbs can be kept in storage for some months and do not perish so easily as the common vegetables. Further, the onion can be cultivated easily and is very remunerative. The normal area under onion is about 22,790 acres in Madras and 30,600 acres in Andhra.

Varieties. There are 2 main types of onion, with some sub types under each, but not such distinct varieties as with other crops. One single bulb alone develops from each plant in the 'Bellary' onion and the 'Dhulia' onion. The individual bulbs are 1 to 2 inches across, globular or slightly elongated and rosy pink or white in colour. The pink or the flesh coloured variety, called the 'Bellary' onion, has a mild pungent flavour and sweet taste. The white variety, called the 'Dhulia' onion, is comparatively flat and insipid. The former is grown in the eastern parts of the Bellary district and the latter in

the western parts, and in small areas here and there over the several districts in Madras and Andhra. Both are propagated by planting bulbs or seeds. Bulbs are planted for the production of seed and seeds alone are used for raising bulb crops.

A number of small bulbs develop in clusters from the base of the plants in the other type. This is the more common type cultivated in South India. The plants are smaller, the leaves are thinner and the bulbs have flavour and taste stronger than those of the 'Bellary' onion. The individual bulbs are slightly angular in section like the sector of a circle in the early stages of development and roughly circular when fully developed. They are $\frac{3}{8}$ to $\frac{3}{4}$ inch across and $\frac{3}{4}$ to $1\frac{1}{4}$ inches in length and rosy pink in colour. There is also a white type, which is bigger and devoid of the twang preferred by the consumers. It is flat and insipid and is not under general cultivation. The small onion is propagated by planting bulbs singly, after separating them from the clusters.

Adaptation. Onion is essentially a tropical crop, which comes up well in hot regions. The single bulbed 'Bellary' and 'Dhulia' onions are grown in subtropical regions also to some extent. They are grown under a variety of conditions from sea level to altitudes of 6,000 feet above sea level.

Light loamy and well drained soils are very suitable for onion, though it is grown in a variety of soils. The small onion is cultivated commonly in red loamy soils in garden lands and even in clay loams in wet lands during the off season. The Bellary onion is grown in the black cotton soils of Bellary and parts of Anantapur, and in loamy garden lands in other places.

Season. The irrigated onion is cultivated mainly in two seasons; the plantings are done in June-July and December to February. They are also planted in small areas in other seasons and a regular supply of onion to the local markets is maintained. Onion is not cultivated during the rainy season in heavy rainfall regions; it is not able to withstand stagnation of water. Onion seedlings are planted in October in parts of Bellary and the crop is cultivated under rainfed conditions, without any supplementary irrigation.

Cultivation. The land is ploughed repeatedly and brought to good tilth. The depth of ploughing is greater than for most other crops. It is manured heavily with 20 to 25 cart-loads of cattle manure and village sweepings per acre and incorporated with the soil by ploughing in Tamil Nad and by working blade harrows in the Ceded districts. It is considered by farmers that sheep penning may affect the quality of the bulbs adversely and is not resorted to. In parts of Bellary, the crop preceding onion is sometimes manured heavily and the onion crop is not manured directly.

Bulb crops. The 'Bellary' onion grown for the production of bulbs is called the 'bulb crop' and when seed is produced, it is called 'seed crop'. Bulb crops are raised in Mysore by broadcasting or drilling the seeds directly in the field. In Tamil Nad and Andhra Desa, the crop is raised by transplanting onion seedlings, raised in nurseries. Four to five pounds of seed sown in 3 cents of nursery provide sufficient seedlings for planting an acre. The seeds germinate in 7 to 10 days and the seedlings can be lifted after about 25 days of growth, when they are 7 to 9 inches high. The field is laid into ridges and

furrows, 18 to 20 inches apart and the seedlings are planted on both sides of the ridges, 4 inches apart. The crop is irrigated once in 4 or 5 days in the beginning and at intervals of a week after the crop gets established and starts vigorous growth. It is hand hoed and weeded 20 to 25 days after planting and again 3 weeks later. The transplanted crop makes rank growth in rich soils, when the plants are slightly trampled down 2 or 3 times, at intervals of a few days. The plants laid down by trampling get erect again in 2 or 3 days. Trampling disturbs the plant system, rank growth is controlled and plant activity is then diverted to the formation of bulbs. Flower heads appear on stray plants 2 months after planting. They are pulled out with the stalk and used as vegetable before the capsule enclosing the flower heads open. If they are left on the plants, seeds develop and interfere with the development of the bulbs ; the quality of the bulbs produced is lowered.

The plants begin to form bulbs 2 months after planting and get ready for lifting in another month. The bulbs are formed near the surface and are partly visible above the soil. Covering the exposed bulbs interferes with their development and should not be done. The crop turns lighter in colour and the leaves start yellowing, when the bulbs mature. The leaves lose their turgidity and begin to flag down and fall back on the stem. The outer layer of scale leaves gets dry, thin and papery. It peels off easily. Irrigating the crop at this stage increases the moisture content and the weight of the bulbs produced, which do not keep long and rot easily in storage. The bulbs have, therefore, to be lifted without irrigation. The plants can be pulled out easily from sandy and loose soils, as the bulbs are near the surface

They have to be lifted from heavy soils by light digging. When the onions can be sold immediately after lifting, the leafy stalks are cut off, leaving about an inch of the stalk attached to the bulbs. If they cannot be sold immediately and have to be kept in storage for some time, they have to be cured properly and their moisture content reduced, as otherwise, they tend to rot. The harvested plants are spread out in shade, in thin layers, for 3 or 4 days, when some moisture is lost from the bulbs. The leafy stalks are then cut and the bulbs are spread out again. The bulbs continue to lose moisture and they can be be kept in small heaps after a fortnight, without deterioration by heating-up and rotting.

Seed crops. For producing 'Bellary' onion seeds, mature bulbs of the summer crop are kept over and planted in October-November, 1 foot apart on one side of ridges, opened 1½ feet apart. About 2,000 to 2,500 lb. of bulbs are required for planting an acre. This is cultivated like the bulb crop. The flower heads appear in about 2 months, set seeds, develop and start drying in another 6 weeks. They are gathered individually, when the thin papery capsules enclosing the seeds start drying. If they are left on the plants longer, the capsules dehisce and the seeds are shattered. The heads are dried and the seeds are separated by flailing with thin bent sticks. Farmers do not produce the seeds they require, but depend upon the seedsmen in Bellary, who arrange for the production, collection and marketing of onion seeds. The seeds lose their viability in one year and have to be produced afresh each year.

Cluster bulb crops. The small type of cluster bulb onion is cultivated under irrigated conditions, more or

less like the 'Bellary' onion. It is grown in loamy garden soils. The individual sectors are separated from the composite bulbs and planted in beds, 4 to 5 inches apart. About 750 to 1,000 lb. of bulbs are required for planting an acre. Sprouts appear above the ground in 10 days and the crop gets ready for harvest in 3½ months after planting. The bulb clusters are not visible on the surface as in the 'Bellary' onion. The crop is dug, the leaf stalks are cut immediately after, the bulbs are spread out in thin layers for curing and the cured bulbs are kept in small heaps, later. When the bulbs have to be kept over for some time, they are kept stacked in trapezoidal heaps with pyramidal tops, like sorghum straw stacks. Such bulb stacks can be seen in parts of Coimbatore. The stacks are 5 feet wide, 6 feet high and of variable length. The bulbs can be kept in stacks for about 2 months and they do not deteriorate during the period.

Yield. The yield of 'Bellary' onion bulb ranges from 10 to 15 thousand pounds per acre and that of seed from 400 to 600 lb. The yield of the small cluster type of onion is 6,000 to 10,000 lb. per acre, with a 8 to 10-fold increase over the seed bulbs planted.

XI. 5. Garlic (*Allium sativum* Linn.)

Vernacular names: Tamil - vellai poodu; Malayalam-velluli; Telugu - thella gadda; Kannada - belluly; Hindi-lasum.

Crop characteristics. Garlic is closely allied to onion and is cultivated more or less similarly. It is a more delicate crop, which is rather sensitive in its requirements of soil, climate and cultivation and its produce is more valuable. It is in common use as a condiment in Indian

cookery. It is considered to be a specific for rheumatic complaints, besides being a liver stimulant and intestinal antiseptic. It keeps well for a long time without deterioration.

Adaptation. Garlic is cultivated in rich, well-drained clay loams, as an irrigated crop, both in garden and wet lands. It does not thrive in hot regions and does not flourish so well in the tropics as in the milder subtropics. Its cultivation is confined to regions with a mild climate as the Udamalpet area of the Coimbatore district, the Kodaikanal Hills, and Bellary, Kadur and Hassan districts in Mysore. The cultivation of garlic is confined to regions, where the underground water used for irrigation is sweet and not brackish.

Distribution. Garlic is cultivated in about 2,700 acres in Madras and 2,500 acres in Andhra State. Madurai district has about 2,000 acres under the crop, East and West Godavari 400 acres each, and Guntur, Kurnool and North Arcot districts 200 acres each; the other districts have negligible areas.

Season. Garlic is cultivated as a pure crop in 2 seasons at Coimbatore, namely (1) June to September and (2) November to March. It has a duration of about 100 days in the first season and 90 days in the other season.

Varieties. Two distinct types having large and small sized bulbs alone are recognised. The small type has a duration of about 3½ months and the big type about 5 months. It cannot be said that these are distinct varieties.

Rotations and mixtures. Garlic is included in the regular rotations of garden lands and follows *ragi*. It is

planted in July-August in the Siruguppa area of the Bellary district in wet lands, as a mixed crop early in the season, and as a pure crop later. It is cultivated in rotation with rice and sugarcane here and there, and as an inter-crop in young banana gardens.

Cultivation. The land is prepared as for other garden land crops and is heavily manured with cattle manure, at 30 to 40 cart-loads to an acre. Sheep are also penned in addition sometimes, at 3 to 4 thousand sheep-nights per acre.

The garlic bulb is a composite bulb, made up of a number of separate sectors held together by a few layers of a papery integument enclosing them. The sectors, called 'cloves', are separated by pressing the bulbs spread over the floor, with the heel of the foot, or sometimes with small planks. The cloves are broadcasted in beds already formed in the field and pressed into the soil by trampling. They are also covered by working hand hoes and blade harrows superficially. The cloves seen on the surface are pressed into the soil at the time of the next irrigation and brinjal seedlings are planted on the sides of irrigation channels. In banana gardens, the garlic cloves are broadcasted in the interspaces between the banana suckers immediately after planting and covered with rakes. The quantity of bulbs planted varies widely; it is as low as 250 to 300 lb. to an acre with the small type and 400 lb. with the big type in South India, while 700 lb. are said to be used in Bombay. The final yield may be expected to be 10 to 12 times the quantity of sectors planted.

The crop is hoed and weeded 3 to 5 times and irrigated once in 4 to 5 days; 25 to 30 irrigations are required at Coimbatore. In Bellary, 10 to 12 irrigations only are

given at intervals of 8 to 12 days, as the crop is planted in wet lands, and the soil is clayey and retains moisture for a long time. The bulbs commence forming in 50 to 60 days after planting. It takes about 6 weeks for the bulbs to develop and the stage of maturity is carefully watched from the 90th day onwards. The crop turns pale green, the tips of the leaves begin to dry up and the bulbs are filled up at the time of maturity. The bulbs are perfectly round in section at the time of development, and longitudinal protuberances and depressions are formed on the surface later, in conformity with the shape of the cloves developing inside. Such changes on the surface of the bulbs indicate their maturity. If the crop is kept in the field longer, the changes on the surface of the bulbs become more pronounced; a light red colour develops on the surface, and the cloves increase in size, tending to burst the outer integument and to get split at the time of harvesting and curing. Split bulbs fetch low prices and they are not in demand in the market. The crop has to be harvested at the correct stage of maturity, that is, within a week of the appearance of the protuberances and depressions on the surface of few bulbs pulled out at random from different parts of the field for periodical examination.

The mature crop is irrigated lightly, 2 or 3 days before harvest, for softening the soil and facilitating the lifting of the bulbs. Those that offer difficulty are levered up with a small piece of bent iron, called '*ambu*'. The bulbs are lifted carefully without bruising, which lowers their value. Their moisture content is then reduced in the following way at Udamalpet. The harvested plants are made into heaped rows, 15 to 18 inches in width and height and variable in length, in the field. The leaves

are kept inside the heap and the bulbs and roots stick out. These are taken out on the 4th or 5th day and the bulbs are separated from the stem and the leaves by cutting. The bulbs are then taken to the yard and spread out in thin layers in the open, exposed to the sun. They are heaped early in the mornings and spread out for drying by about mid-day, for 4 or 5 days. While spreading daily, they are taken in baskets and allowed to fall to the ground from a height of about 2½ feet. This dislodges the mud and the dry scale leaves sticking to them. The produce is then winnowed and formed into small ridges, 1½ to 2 feet wide, 1 foot high and 15 feet long in open shady verandahs. Adjacent ridges are 3 to 4 feet apart and the intervening space is required for turning the heaps on alternate days. The moisture content of the bulbs is reduced to the appropriate level in the course of a fortnight. When the bulb is cured sufficiently, the cut end of the stem above the bulb is dry and can be ignited readily with a lighted match stick. The bulbs are then packed in bags. These are piled one over another, to a height of 4 bags; piling more bags presses the lower bags and damages them.

The yield of the small type of garlic is 3,000 to 5,000 lb. of cured bulbs per acre and of the big type 4,000 to 6,000 lb.

The garlic produced at Coimbatore is of the small type, having a strong characteristic odour, and it is in demand in Ceylon, Tiruchirapalli, Tanjore, Madurai and Tirunelveli markets. The big type produced in the Kodaikanal Hills and Travancore is not so strong and it is imported into Coimbatore, for meeting the local demand. The Bellary garlic is exported to Bombay market.

XI. 6. Coriander (*Coriandrum sativum* Linn.)

Vernacular names: Tamil - kothamalli; Malayalam - kothampalari; Telugu - dhaniyalu; Kannada - kothambri; Hindi – dhaniya.

Coriander is cultivated for the production of seed as a regular field crop and of green leaves for use as pot-herb on a small scale in vegetable gardens. Both the green plant and the seed have a mild aroma and are used as a common condiment in Indian cookery. The aroma is derived from the volatile oil, which is a constituent of the seed and the plant. The seed is a mild appetiser, carminative, sedative and tonic.

Adaptation. Coriander is mainly a crop of the tropics and is cultivated in large areas in India, Russia, Morocco, Africa, Turkey, Palestine and the Balkan countries. It is cultivated as a rain fed crop in the black cotton soil areas throughout South India. It is also cultivated in the red loamy soils as an irrigated crop, particularly in the Coimbatore district and as a pot-herb in most vegetable gardens in South India. The crop intended for pot herb is manured heavily and irrigated liberally for promoting vigorous growth.

Distribution. Coriander is cultivated in about 48,000 acres in Madras and 70,000 acres in Andhra State. Guntur has about 30,000 acres, Tiruchirapalli 18,000 acres, Tirunelveli 15,000 acres and Anantapur 13,000 acres; the other districts have small areas only under the crop.

Cultivation. Coriander is cultivated commonly as a dry crop in black cotton soil areas, either as a pure crop, or mixed with cotton or blackgram. It is grown in

garden lands as a pure crop, in rotation with other garden crops.

Dry lands are ploughed 4 or 5 times and coriander is sown with the onset of the north-east monsoon, without any manuring. The seeds are spread over hard floor and pressed under feet at the time of sowing, when the seeds get split into 2 equal halves, called 'mericarps'. Each mericarp gives rise to a plant. The mericarps are broadcast at 10 to 12 lb. to an acre and covered by ploughing. When coriander is sown with cotton, the two seeds are mixed in the ratio of 1 : 10. The coriander seeds germinate in about a week. The crop is hoed once or twice and weeded. It gets ready for harvest in 3 to 3½ months, when the seeds get ripe and the leaves start drying and shedding. The plants are pulled out in the morning, collected and made into convenient loads, and taken to the threshing floor. They are dried for 2 or 3 days and threshed under the feet of cattle, laying the plants in thick layers to prevent the splitting of the seeds into mericarps. Small quantities are threshed by flailing with bent sticks. The dry plants are sometimes stacked at Coimbatore, with the roots sticking out and the shoots inside, and taken for threshing after a fortnight. There is slight fermentation in the stack and this is considered to improve the flavour of the seeds.

Garden lands are manured with 10 to 15 cart-loads of cattle manure per acre, before the final ploughing. Beds and channels are formed for irrigation and irrigations are given once a week during rainy periods. Otherwise, the crop is cultivated as in dry lands.

The yield of coriander seeds is 300 to 400 lb. per acre in dry lands and 700 to 1,000 lb. in garden lands.

Most of the coriander produced in the country is consumed locally. A small quantity is exported to Ceylon, where it has to compete with Russian and Moroccan produce, which are richer in volatile oils, free of extraneous matter and better in quality. The Indian produce is variable in quality and is reported to include foreign matter to a considerable extent. Cleaning, grading, maintenance of quality, etc., have to receive greater attention at the hands of producers and the various marketing agencies, including middlemen, for raising the prestige and dependability of the Indian produce and the Indian market, not only with regard to coriander, but to all commodities in general, with a view to build and maintain foreign markets.

XI. 7. Pepper (*Piper nigrum* Linn.)

Vernacular names: Tamil - milagu; Malayalam - karu or nal milagu; Telugu - mirialu; Kannada - menasu; Hindi - kali mirch.

Crop characteristics. The term 'pepper' is generally used for denoting pungent condiments, furnished by the genera '*Piper*' and '*Capsicum*'. 'Black pepper' is the whole berry produced by the plant '*Piper nigrum*', which resembles the betel vine in general appearance and belongs to the same family. If the black epidermal layer is removed while curing the berry, the produce obtained is creamy white and is called 'white pepper'. The chilli is called 'cayenne pepper'. or 'red pepper.' The term 'pepper' is used here for the plant *Piper nigrum* and its berry.

Pepper is a popular condiment which is in every day use with food of many types, all over the world. It is a carminative and expectorant, which is used freely in the

Indian system of medicine and frequently as a home remedy along with ginger and long pepper, for minor alimentary and respiratory disturbances.

Pepper appears to have been known in India from very early times and reference is made to it in early Sanskrit literature. Wild forms of the plant are found growing in the hilly jungles of Malabar and of the Northern Circars, and India is probably its original home. It may have spread from India to other countries like South-East Africa, Ceylon, Indonesia, West Indies etc. where it is being cultivated now.

Adaptation. Pepper is essentially a crop of the humid tropics, requiring a warm climate and a humid atmosphere. These prevail in tropical areas, which have over 70 inches of annual rainfall. It comes up well under the shade of trees with sparse foliage, which further serve as support for the pepper vines to climb. The trees also provide shelter from wind and pepper comes up better on their leeward side in regions subject to windy seasons. Pepper is largely cultivated in the plains, though it comes up in altitudes up to 4,000 feet above sea level.

It can be grown in a variety of soils, excepting in very light soils. Thus, in the West Coast, the cultivation of the crop is confined to the inland areas, which are clayey or loamy and not in coastal belts which have light sandy soils. It requires satisfactory drainage and does not withstand stagnation of water. Where the natural drainage is defective, suitable open drains have to be formed for leading surplus rains out of the land. It is also partial to the organic matter content of the soil and

comes up well in forest soils and wooded areas, subject to enrichment with considerable leaf fall. As a result of the varied requirements of pepper like warm climate, humidity of the atmosphere, shade, support for the vines, shelter from winds, effective drainage and a high organic matter content in soils, its cultivation is confined naturally to regions, where the environmental conditions are favourable in respect of all the factors concerned.

Distribution. Pepper is produced on a commercial scale in India, Ceylon, Indonesia, Malaya, Siam, Phillipines and the West Indies. The cultivation of the crop in India is confined to a narrow belt favoured by the south-west monsoon from Cape Comorin in the south to Konkan of the Bombay State in the north. Travancore-Cochin and Malabar have large areas under pepper. Moderate areas are devoted to it in South Kanara and North Kanara. It is grown in small areas in the 'Malnad' of Mysore, Assam and portions of Bengal adjoining it. India is the largest producer of pepper after the second world war, when plantations in Indonesia and South-East Asia were neglected and damaged. The area under the crop in the Indian Union is 208,500 acres, of which 2,300 acres are in Bombay, 85,800 acres in Travancore-Cochin, 118,700 acres in Madras and 1,700 acres in other States. Malabar has 101,000 acres and South Kanara 16,000 acres. The production of pepper in the Indian Union ranges from 400,000 to 450,000 cwts. annually, with Malabar contributing about 140,000 cwts., South Kanara 25,000 cwts. and Travancore-Cochin 250,000 cwts. Of the net world export of 563,000 cwts. of pepper in 1953, India accounted for 229,000 cwts., followed by Sarawak and Malaya.

Varieties. There are several varieties of pepper under cultivation, with variation in the shape of the leaves, habit of climbing, size of berries, colour of ripe berries etc. The important varieties in Malabar are 'Kalluvalli', 'Balamkottah', 'Uthirikottah' and 'Cheriakodi'. The first three bear bisexual flowers and are hermaphrodite, and can set and bear berries. 'Cheriakodi' bears unisexual flowers only, either male or female, and the latter alone can set and bear berries.

Cultivation. Hill slopes which provide protection against wind and which have red loamy laterite and clay loams alone are selected for the cultivation of pepper. Scrub jungle land is cleared and unwanted trees and plants are uprooted. Trees that can serve as support for pepper vines are left behind. Quick growing trees which provide light shade like *kalyana murungai* (*Erythrina indica*), *Kapok* (*Eriodendron enfructosum*), silver oak (*Grevilla robusta*) and *Gliricidia maculata* are planted 8 to 12 feet apart in April with the summer showers and the land is thoroughly dug. Pepper can also be planted in existing jack, mango and arecanut gardens and trained on the standing trees. In orange and coffee plantations, pepper vines are trained on silver oak and other trees which are interplanted as shade trees. Pepper can be even trained on stone and wooden posts. The number of pepper vines planted in an acre varies with the type of garden. Coffee plantations, and jack and orange gardens may have 70 to 80 plants per acre, areca gardens 120 to 150 plants and pure pepper gardens may have 300 or more plants.

Pepper can be established by planting fresh cuttings of vines, rooted vine cuttings, layers or seedlings. The

seedlings produce heterogeneous plants of uneven bearing and are not used for propagation, ordinarily. The cuttings are taken from vines bearing bisexual flowers, when all the flower spikes can bear fruits. Cuttings from vines bearing female flowers are next best and 2 or 3 male plants have also to be planted along with, for effecting the fertilisation of the female flowers. Certain plants are naturally robust and bear heavily and uniformly every season. Such vines provide the ideal planting material.

After the standard saplings establish in new areas, pits 15 to 18 inches cube are dug on the leeward side of the saplings. They are filled with rich forest soils, and cattle manure at about 20 lb. per pit. Pepper is planted in August-September, when the south-west monsoon starts weakening. Five to eight unrooted cuttings, about 3 feet long, are planted in each pit. The basal half of the cutting is buried in the soil and the top is laid over the ground pointing to the standard. Many of them do not root properly and one or two only get established finally. One or two rooted cuttings or layers can be planted instead of unrooted cuttings. After planting, the pits are filled and the top surface is made sloping, so that rain water does not collect at the base of the vines. The young pepper plants grow vigorously and only one main stem is allowed to develop by pinching the side shoots. The main stem is tied to the standard periodically in the early stages. This becomes unnecessary later, when the vines send out aerial roots and get anchored to the standards firmly. After cultivation and maintenance operations are few. About 30 lb. of cattle manure are applied round the base of each vine every year and mixed with the soil. The standards and vines are pruned and kept within a manageable height to enable

the pepper berries being gathered easily, with the aid of small ladders.

Harvest. The pepper plant established by planting cuttings from fruiting branches start bearing in a year, but the flower spikes produced are rubbed off and not allowed to bear for about 3 years. The cuttings, from branch vines which had not flowered on the original mother bushes, produce plants which come to bearing in about 4 years. Flowers are borne on spikes and there is profuse flowering in the month of July, but all the flowers do not set and the crop produced is variable. The harvest is commenced when a few berries in a garden turn bright orange in colour, sometime in February-March and the fruit spikes are detached from the vines. The berries are separated from the spikes by rubbing the spikes with the hand or by trampling, and spread out on the floor for drying. Drying is completed in 6 or 7 days during bright weather. The dry berries are black in colour and have a crinkled surface. They go by the name of 'black pepper'.

Pepper for one's own home use and to a small extent for export to special markets is cured differently. The spikes are gathered after a large number of berries get ripe on the spikes themselves, that is, at a stage later than that for the general harvest. The spikes are kept heaped up for 1 or 2 days, when the berries change colour and get fully ripe. The berries are then separated from the spikes, soaked in water for a day and kept covered in heaps later. The outer pulp surrounding the hard seeds ferments in the heap and gets softened. The berries are rubbed vigorously between the hands and the seeds are washed free of the pulp and dried in the sun.The dry seeds

are creamy white in colour and go by the name of 'white pepper.' The pungency and flavour are lost to an extent by the removal of the outer pulpy layer. The substances that give the flavour and pungency in pepper are the pepper oil, pepper resin and the alkaloid 'piperine'. These are present in the outer pulp also and their removal accounts for the reduction of the flavour and pungency of the white pepper.

Pepper is also collected from the wild pepper vines growing in the forest areas of Malabar. The berries obtained are very variable in quality, shape and size and go by the name of 'wild pepper' in the market.

The yield of pepper is uncertain and ranges from 2 to 8 lb. of dry pepper or more per bush. An average yield may be taken to be 1 cwt. of pepper per acre in mixed plantations, and 3 cwts. in pure pepper plantations. Yields up to 3,000 lb. per acre are said to be obtained in Malaya.

CHAPTER XII

FIBRE CROPS

XII. 1. Cotton (*Gossypium* sp.)

Vernacular names: Tamil and Malayalam - paruthi: Telugu - pathi ; Kannada - hathi ; Hindi - rui.

The English word 'cotton' and the various vernacular equivalent names denote both the plant and the raw produce obtained from it, which is the foremost textile fibre in the world today. The word 'cotton' has possibly been derived from the Arabic word 'kutun'.

Origin. The archaeological evidences furnished by the excavations in the Indus valley indicate that the use of cotton was known in India from very early times. The fibres in the fragments of cotton cloth unearthed are similar to those of the indigenous cottons grown in India at present. The Indus civilisation dates back to 3,000 B. C. and the cultivation of cotton, spinning yarn and weaving cloth were in vogue even then. Specific references to cotton are made in the *Manu Sutras* (Vedic literature) of 800 B. C. The history of cotton is lost in antiquity. Cotton was cultivated and used in the manufacture of cloth in the New World in 1492 A.D., at the time of its discovery by Colombus. India is considered to be the birth place of cotton and of the manufacture of cotton cloth. She was the leading cotton growing and manufacturing country till the middle of the 19th century, when the industrial revolution of the West brought about technical improvements in cotton

spinning and weaving, and relegated India to the background; she became merely a producer of raw cotton.

Adaptation. Cotton is essentially a tropical crop and its cultivation is mainly confined to 30° Latitude on either side of the equator. The Southern States of the U. S. A., India, Pakistan, China, Brazil, Southern parts of U. S. S. R. and Egypt are important cotton growing areas of the world. Cotton is of moderate importance only in the other Equatorial countries. It is mostly cultivated in the plains at low elevations, though it can be grown in altitudes up to 2,500 feet above sea level.

A mean temperature of 80° to 90° F. appears to be most suitable for the cultivation of cotton. It does not tolerate minimum temperatures below 60° F., though the maximum temperature can go up to 95° to 100° F., during the growing period and 105° to 110° F. during the period of maturity of the bolls.

Cotton is cultivated as a rain fed crop in regions having an annual rainfall of 20 to 35 inches. It comes up well even when there are no rains during the growing period, when the soil is retentive and has at the time of sowing sufficient moisture for its growth. Thus, in the Bellary region, the rainfall from June to September is about 15 inches and cotton is sown in the deep retentive black soils during September, after the cessation of the monsoon rains. No rains are received during the growing period in some years and the crop struggles through and yields some produce. It does not tolerate heavy rains, though it is grown in the uplands of the Circars, where the rainfall amounts to 30 inches or more during the growing period. But the light red soils of the area, where cotton is grown, are well drained and water does not stagnate in the soil for any length of time.

Soils. Cotton thrives best in deep clays and clay loams, though it is grown in a variety of soils. Most of the rain fed cottons are cultivated in the heavy black cotton soils in South India. The American type of Cambodia cotton is grown in red loamy soils and moderate clay loams, under irrigation. The summer Cambodia is cultivated in clayey wet lands in parts of Ramanathapuram and Tirunelveli. Very light and gravelly soils are not quite suitable for cotton, though even here, hardy types like the 'Nadam', 'Bourbon' and 'Moco' are grown in Salem and Coimbatore districts and *mungari* cotton in the light, red and shallow soils in parts of Bellary, Anantapur and Kurnool.

Name of country	Extent in acres	Production of lint in bales of 392 lb.	Average yield of lint in lb. per acre
	(1,000s)	(1,000s)	
North America	27,751	20,210	286
U. S. A.	25,664	18,530	283
Europe	646	311	189
U. S. S. R.	5,700	4,285	295
Asia	32,536	10,440	126
China	9,350	3,477	146
India	16,175	3,489	85
Pakistan	3,413	1,775	195
South America	7,008	3,363	184
Argentina	1,385	735	208
Brazil	4,800	1,837	150
Peru	469	545	455
Africa and Oceania	7,759	4,156	210
Anglo-Egyptian Sudan	617	463	294
Belgian Congo	790	245	122
Kenya	56	9	60
Uganda	1,592	338	83
Egypt	2,042	2,448	470
World Total	82,500	43,310	206

Source: *Based on U. S. D. A. Agrl. Statistics*, 1953—'54.

Distribution. The world situation with regard to the cultivation and production of cotton and the textile industry has undergone rapid changes during the last 30 years, principally due to the impact of the world wars and the changing economic structure of the industrial countries. In the post war II period, the acreage and output of cotton have been fluctuating in the several countries cultivating cotton, including India, where the partition of the country in 1947 was an additional influencing factor. India holds today the second place with regard to acreage and the third place with regard to the production of raw cotton in the world. The world extent and production of cotton during the year 1952 were as in page 450.

Among the Indian States, Bombay, Madhya Pradesh and Hyderabad lead in extent with 3·2 to 3·8 million acres each. The other important States are Madras, Andhra and East Punjab, with 5·8 to 8·5 lakhs acres each. The others have small areas only. The extent and production of cotton in the important States in India during the year 1953—'54 are given below:

Name of State	Extent in acres	Production of lint in bales of 392 lb.
	(1,000s)	(1,000s)
1. Andhra	659	97
2. Bombay	3,836	1,092
3. Hyderabad	3,281	381
4. Madras	849	262
5. Madhya Pradesh	3,657	647
6. East Punjab	588	365
7. Other States	4,157	1,091
All-India Total	17,027	3,935

Source: '*Agrl. Situation in India,*' July. '54, p. 224.

The extent and production of cotton during the year 1952 - '53, in Madras and Andhra States, district-wise, are given below:

Name of District	Extent of cultivation in acres			Production of lint in bales of 392 lb.
	Irrigated	Rain-fed	Total	
1. MADRAS				
Chingleput	192	116	308	120
South Arcot	950	10,584	11,534	1,800
North Arcot	32	409	441	60
Salem	5,623	18,074	23,697	6,920
Coimbatore	74,372	161,631	236,003	82,090
Tiruchirapalli	5,779	14,920	20,699	6,720
Tanjore	285	218	503	200
Madurai	10,568	93,535	104,103	29,560
Ramanathapuram	25,003	83,595	108,598	25,580
Tirunelveli	18,812	201,484	220,296	59,600
Malabar		1,189	1,189	290
South Kanara		85	85	10
Total-Madras	141,616	585,840	727,456	213,950
2. ANDHRA				
Srikakulam		885	885	100
Visakhapatnam	56	2,494	2,550	320
East Godavari	1,921	309	2,230	380
West Godavari	2	10	12	
Krishna		1,764	1,764	290
Guntur	9	19,704	19,713	3,390
Kurnool } Anantapur }	42,225	417,097	459,322	49,800
Cuddapah	320	34,692	35,012	3,350
Nellore	359	21,152	21,511	3,500
Chittoor	22	13	35	10
Total-Andhra	44,914	498,120	543,034	61,140

Source: *Madras Government, Season and Crop Report of the Madras State for the year 1952 – '53*, 1955.

Coimbatore, Tirunelveli, Ramanathapuram and Madurai in Madras, and Kurnool, Anantapur and Cuddapah in Andhra are important areas for cultivation of cotton.

Specific terms. The following terms are used specifically with reference to cotton and its products:

Cotton fibre. Cotton fibres are unicellular outgrowths from the epidermal layer of the cotton seed coat and are composed of cellulosic material. The fibres are of two kinds, the long and the short, called the 'lint' and the 'fuzz' respectively. The lint is the raw produce of commerce. The lint fibres are 5/16″ to 2¼″ long and are of varying diameter according to the variety. They have a lumen of empty space in the centre, running the entire length of the fibre. It has a third of the cell width and enables the fibres to get twisted by themselves. This natural twist facilitates spinning and is characteristic of cotton fibres, as distinguished from silk cotton and synthetic fibres. The cell walls get thickened by the deposition of cellulose, as the fibre develops. The lint fibres are classified as mature, half-mature and immature, depending upon the degree of secondary deposition of cellulose on the cell walls.

The fuzz is short, ranging in length from 1/64″ to 1/16″. It is thicker than lint and has no twists. It does not get separated from the seed at the time of ginning. It is not of much use commercially.

Kapas and lint. The raw produce obtained from the plant is termed 'kapas' or seed cotton and comprises seed and lint. The lint fibres get separated from the seed at the time of ginning and the cotton freed of seed is called 'lint'.

Ginning percentage. The ratio of lint to seed-cotton expressed as a percentage is called the 'ginning percentage'. It is an important varietal character, which largely determines the yield of lint.

Mean fibre, staple and halo lengths. Cotton is valued for its spinning performance and this is largely dependent on the length of the lint fibres. The length of the fibres in a sample of lint is variable. The percentage distribution of the different length groups of the fibres is determined in the laboratory with suitable instruments. From this distribution, the average length of fibres, called the 'mean fibre length' is calculated.

In trade, cotton samples are judged on the basis of the 'modal length', that is, the length of the maximum number of fibres in each sample. This is called the 'staple length' and is ordinarily expressed in inches, as 7/8", 1 and 3/16" etc. The mean fibre length and staple length differ from each other, depending upon the distribution of the fibre length groups in the sample.

In breeding experiments, thousands of samples are handled and it is not possible to determine the mean fibre length of each sample, as it is laborious and time consuming. Hence, a few seeds from the produce of each plant to be studied are combed and the fibres are spread out in the form of a 'halo' and the maximum length of the fibres is measured in millimeters. This is referred to as the 'halo length'.

Yarn. The cotton fibres are capable of being spun into thread, due to the natural twists possessed by them. The fibres cling together during spinning and 'yarn' is produced.

Spinning value. The number of 'hanks' or 'skeins' of 840 yards each, into which a pound of cotton is spun,

expressed as 40's, 60's, 80's etc., is called the 'spinning value' of the cotton, or the 'count number' of the yarn. Fine yarn has a high spinning value and a large number of hanks are produced from each pound of lint.

Classification. Botanically, the cotton plant belongs to the genus *Gossypium*, falling under the natural order of '*Malvaceae*'. Twenty different species of *Gossypium* have been described so far and the cultivated cottons are confined to four species alone; the rest are either wild or semi-wild.

The important commercial cottons of the world are the 'American Uplands' grown in U.S.A, with 1″ to 1¼″ staple, the 'Egyptians' with 1½″ staple and the 'Sea Islands' with 1 and 5/8″ to 2″ staple. Cotton varieties that are in general cultivation in India belong to 3 species, namely *arboreum* L. and *herbaceum* L., which form the Old World group of cotton, called the 'Desi' or the 'Asiatic cottons', and *hirsutum* L. of the New World group, termed the 'American cottons'. Attempts are also being made in parts of Madras and Mysore to establish 'Egyptian' and 'Sea Island' cottons, belonging to the fourth species, namely *barbadense*.

The chief commerical cottons of India from the point of acreage are the 'Southerns', 'Oomras', 'Jarilla', 'Central Indias', 'Dholleras'. 'Bengals', 'Hyderabads', 'Gaorami' etc. In production, the order is 'Bengals', 'Oomras', 'Jarillas', 'Americans', 'Dholleras' etc., while from the point of quality 'Cambodias' and 'Americans' occupy an important place. The varieties grown in Madras and Andhra States, their botanical classification, regions of growth with soil type, rainfall, extent and production during the year 1952 - '53 are as follows :

South Indian cottons — distribution, characteristics etc.,

Commercial variety	Botanical classification	District where grown	Suitable soil type	Suitable rainfall	Normal extent in acres	Normal production of lint in bales of 392 lb.
Cambodia	*G. hirsutum* race *latifolium*	Chiefly Coimbatore, Salem, Tiruchirapalli, Madurai, Tirunelveli, Ramanathapuram and South Arcot.	Red loamy and light black	25″ - 35″	257,790 (M) 20 (A)	134,250 (M) 10 (A)
Tinnevellies, or Tinnies	Mixture of *G. arboreum* race *indicum* and *G. herbaceum* race *wightianum*	Madurai, Ramanathapuram and Tirunelveli.	Black and light black	24″-35″	475,500 (M)	112,750 (M)
Karunganni	*G. arboreum* race *indicum*	Coimbatore, Madurai, Ramanathapuram and Tirunelveli.	Black and light black			
Uppam	*G. herbaceum* race *wightianum*	Restricted to isolated areas in Tinnies region, Coimbatore, Salem and Tiruchirapalli.	Light black	25″ - 30″	9,950 (M)	1,570 (M)

Nadam and Bourbon	Mixture of *G. arboreum* race *indicum* and *G. hirsutum* race *punctatum*	Coimbatore and Tiruchirapalli	Light red and gravelly	20″ - 30″	1,420 (M)	70 (M)
Westerns-Hingari or Jowari	*G. herbaceum* race *wightianum* mainly	Cuddapah, Anantapur, Kurnool and Bellary (part of Mysore, now)	Deep black	18″ - 22″	707,710 (A)	87,110 (A)
Westerns-Mungari	*G. arboreum* race *bengalense*	Anantapur and Bellary (part of Mysore, now)	Deep black			
Northerns-white and red	Mixture of *G. arboreum* race *indicum* and *G. herbaceum* race *wightianum*	Kurnool	Light black and red	22″ - 28″	102,130 (A)	8,420 (A)
Coconadas	*G. arboreum* race *indicum*	Guntur, Krishna, Nellore, Godavari and Visakhapatnam	Light black and red	30″ - 33″	66,390 (A)	12,120 (A)
Chinnapathi	*G. arboreum* race *bengalense*	Visakhapatnam and Godavari	Light black and red	40″	2,950 (A)	370 (A)

Source: *Season and Crop Report of the Madras State for the year 1952—'53*, Madras Government, 1955.

Note.—In extent and production in the last two columns, (M) refers to Madras and (A) to Andhra.

The several commercial types of cotton are confined to distinct zones, as seen above. Though the general pattern of cultivation is the same, the methods of cultivation of the different types are distinctive and they are considered below briefly.

1. Cambodia cotton

Cambodia is an exotic variety of cotton, which was first introduced into South India during the year 1904 from Cambodia in Indo-China and it has taken its name from the place of its origin. It is an American type. Its cultivation has now spread to nearly 2·6 lakhs acres, with more than half the area under irrigation from wells or tanks. It is grown in well - drained, red, loamy soils in the districts of Salem, Coimbatore, Tiruchirapalli, Madurai, Ramanathapuram, Tirunelveli and South Arcot. It is raised in two different seasons, that is, (1) the cold weather or winter, and (2) the summer months. The major area is cropped in winter, during the period September to April. The summer cotton is called 'Masipattam' cotton and is usually sown during the last week of March and harvested in July-August, in garden lands and wet lands in Ramanathapuram, Tirunelveli and Madurai districts. It is sown from January to March in South Arcot, where facilities exist for well irrigation. The sowings of the rain fed Cambodia cotton in Tamil Nad are done with the break of the north-east monsoon in September-October. The rain fed crop in South Arcot is raised in December and has to be classed as summer cotton only.

Preparatory cultivation. For irrigated Cambodia, the land is ploughed 4 to 6 times and brought to good tilth.

FIG. 42. A good crop of Cambodia cotton.

Courtesy:—Director of Agriculture, Madras.

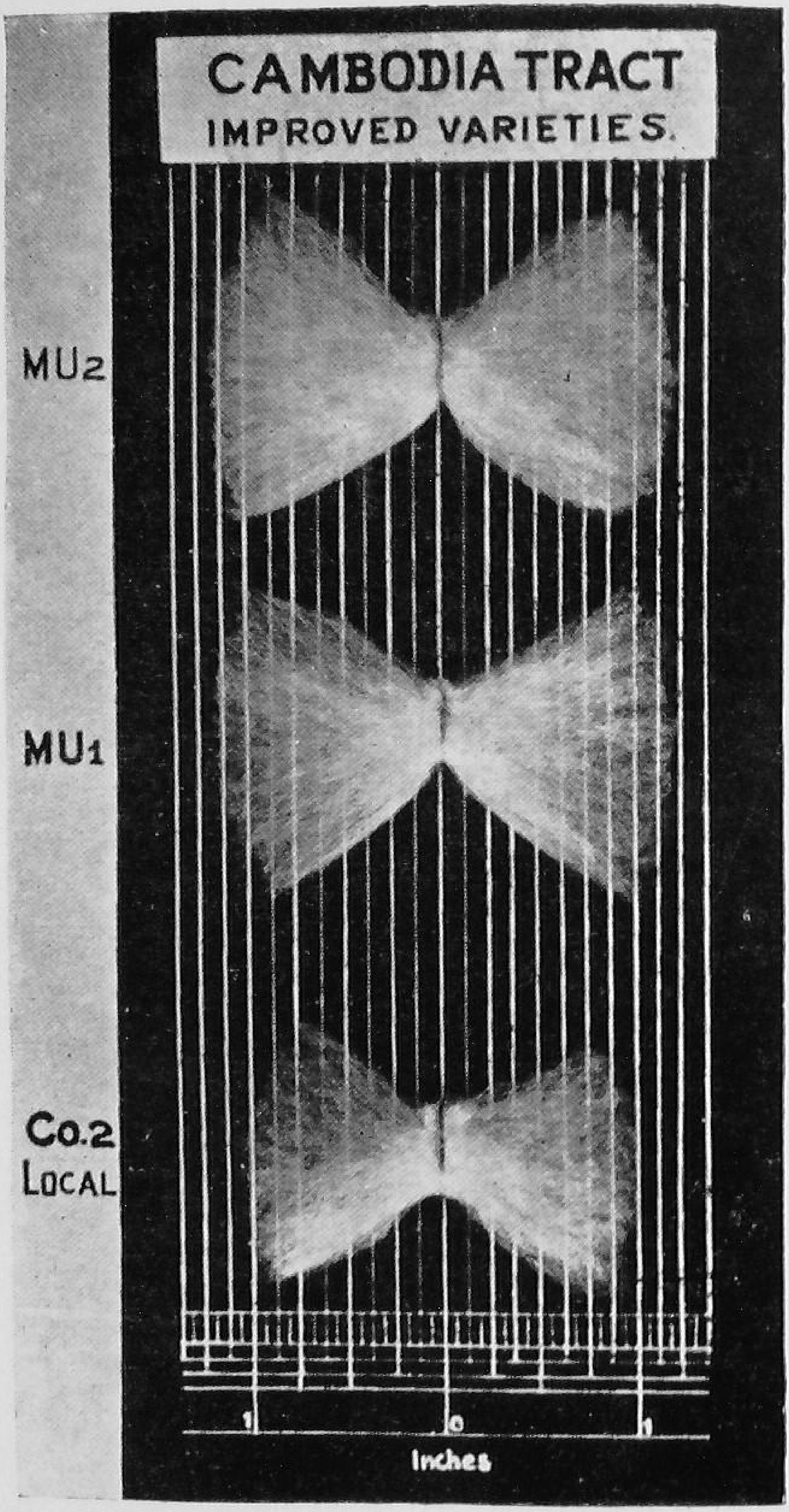

FIG. 43. Cambodia cotton seeds combed out in the form of a halo, to show the length of the fibres.
—*Courtesy*: *Director of Agriculture, Madras.*

The seeds are either broadcasted and covered by ploughing, or dibbled on ridges, formed 2½ feet apart. Sowing on ridges facilitates the use of labour saving implements worked with bullocks for intercultivation. It also economises irrigation water.

The optimum seed rate for the ridge sown crop is 8 to 10 lb. to an acre. The spacing between plants in the row is 9 inches and it gives a population of 24,000 plants to an acre. In the Coimbatore taluk, where cropping is done intensively, Cambodia cotton can be planted advantageously in September and harvested in March, and sorghum can follow and be on the land up to July. In other parts of Coimbatore and Salem, Tiruchirapalli and Madurai districts, the prevalent rotation is *ragi*-cotton or *cumbu*-cotton, with the cereal coming in in June-September and Cambodia in October-April. The advantage of raising Cambodia early in September cannot be extended to these areas and the tendency to low yield caused by late raising has to be overcome with a smaller spacing of 4 inches between plants in the row. A seed rate of 15 to 30 lb. per acre is adopted for broadcast crops, and beds and irrigation channels are formed after covering the seeds.

The use of improved strains of seeds is common for both the winter and summer crops. The Cambodia-2 (Co. 2) strain is suitable for winter sowings. The Madras Cambodia-Uganda-1 (M.C.U. 1) strain, a cross between Cambodia-2 and African Uganda is 3 weeks earlier than Co. 2 and it has now largely replaced it in the winter tract. It is particularly suitable for summer sowings, where earliness of the crop is particularly desired. A new strain M.C.U. 2 is now recommended for cultivation in the summer tract, in place of M.C.U. 1.

Manuring. Cotton is not manured directly, in general. The usual practice is to apply heavy doses of cattle manure mixed with tank silt to the preceding cereal crop. Experiments conducted in South India indicate that the cotton crop benefits by direct application of fertilizers. Irrigated Cambodia can be fertilized with 2 cwts. of ammonium sulphate per acre, one cwt. at the time of the last ploughing and the second cwt. at the time of the formation of the flower buds, just after hoeing and weeding, followed by heavy irrigations. Rain-fed Cambodia can be fertilized with 1 cwt. of ammonium sulphate per acre at the time of sowing. Groundnut cake is as efficient as ammonium sulphate on an equal nitrogen basis and 250 lb. of the cake can replace 100 lb. of the sulphate.

Irrigation. Irrigated crops are given an irrigation on the day of sowing and a second one 4 days after, when the seeds sprout. Irrigations are given later, when the plants droop during the mid-day. Under the conditions prevailing at Coimbatore, irrigation has to be provided once in 3 weeks, and oftener for sandy soils and also for the summer crop. Heavy irrigations are required during flowering and development of bolls, for facilitating good boll setting and proper maturity of the fibres.

After-cultivation. The young plants are thinned to one plant per hole, when they are 6 to 9 inches high and weeded when necessary. Broadcast crops are hoed with spades, at 6 or 7 weeks. Line sown crops are hoed and ridged up with suitable cultivating implements.

Harvest. Cambodia bolls open by about the fifth month after sowing and the *kapas* are exposed. The

kapas should not be left on the plants for a long time after bursting, as they get soiled with dust, broken leaves and bracts. Picking *kapas* is best done early in the morning and the produce dried in the sun for a while, before storing. If the picking is done later in the day, leaves and bracts on the plants get detached during handling and stick to the *kapas*. The normal yield of Cambodia is 1,000 lb. of *kapas* per acre, while under favourable conditions the yields touch 2,500 lb.

The yield and quality of the summer Cambodia are better than those of the winter crop, which form the bulk of the Cambodia under cultivation. The shedding of the bolls and the incidence of pests and diseases are less in the summer crop. Earliness of the crop and uniformity in the bursting of the bolls leading to a short picking season are special features of the summer crop. There is improvement in the length of the staple and in the maturity of the fibres of the summer crop. Side by side, the seed weight and size are increased, with a consequent fall of 3 to 5 per cent in the ginning out-turn. The summer crop is not able to adjust itself to out of season plantings. Thus, a Cambodia crop raised in South Arcot from March to September is subject to abnormal flower shedding, imperfect opening of the bolls and low yields, though it is apparently normal in appearance. The crop sown in December is, on the other hand, free of the above defects and gives 3 times the yield of the March sown crop.

2. Tinnies and Karunganni cottons

The indigenous cottons grown on the rain fed black soils of the Coimbatore, Madurai, Ramanathapuram and Tirunelveli districts are known as 'Tinnies' (Tinnevellies)

and 'Karunganni'. The former comprises 'Karunganni', 'Uppam' and a variable mixture of these two varieties. Of late, 'Karunganni' has mostly replaced the others. In parts of Salem and Tiruchirapalli, pure 'Uppam' is also cultivated to some extent, which along with the perennial 'Nadam' and 'Bourbon' cottons form the commercial type, called the 'Salems', which is of minor importance only.

Season. 'Tinnies' and 'Karunganni' are grown during the north-east monsoon season. The sowings commence towards the end of September and extend up to November.

Rotations and mixtures. Major portion of 'Karunganni' in the Coimbatore district is grown pure, while in some parts, *tenai*, coriander, Bengalgram and blackgram are grown mixed with cotton in ratios ranging from 1:4 to 8 of cotton. The prevailing rotations in Coimbatore area are sorghum-cotton and horsegram-cotton. Cotton is also grown year after year on the same land, in parts of Palladam and Udamalpet taluks.

In Ramanathapuram, half the area under cotton is usually grown mixed with blackgram, or groundnut, while the rest is under pure cotton. In the Tirunelveli district, only a third of the area is under pure cotton and the rest is under mixed cropping with blackgram, coriander and *tenai*. The prevailing common rotation in both the districts is fodder sorghum-cotton, or *cumbu*-cotton, mostly the latter.

Cultivation. The land is ploughed 2 or 3 times and brought to good tilth. Cotton seeds are broadcasted on receipt of a good soaking rain in September-October, or rarely even in November. Drilling is rarely done. The

seed rate used for broadcasting is 10 to 20 lb. to an acre, depending upon the system of cropping, that is, pure or mixed. The cotton crop is not manured directly, but the preceding fodder sorghum and *cumbu* are manured heavily with cattle manure, compost, or groundnut cake. This system has possibly developed as a result of shortage of manure. When manure is available over and above what is required for the cereal crops, it is applied directly to the cotton crop. In parts of Pollachi taluk in the Coimbatore district, cattle are penned at 500 head per acre. Experiments in the 'Tinnies' area indicate that 'Karunganni' can advantageously be fertilized with ammonium sulphate, at 1 cwt. per acre and that increases in yield of about 70 lb. of *kapas* per acre may be expected in years of favourable rainfall. The seedlings are thinned sometimes allowing 6 to 9 inches between plants and the crops are hand - hoed twice, to keep them free of weeds.

The bolls commence bursting 5 months after sowing towards the end of February, or early in March. The normal yield of 'Karunganni' ranges from 300 to 350 lb. of *kapas* per acre in pure crops. The yield of mixed crops varies with the proportion of cotton in the mixture.

In parts of Coimbatore and Madurai, 'Karunganni' is also grown under irrigation, sometimes. This is manured with cattle manure or tank silt at 15 cart-loads per acre. The yield ranges from 800 to 1,000 lb. of *kapas* per acre.

3. Uppam cotton

This is a short staple, coarse linted variety of cotton of minor importance. It has a low ginning percentage. It withstands drought extremely well and is grown as pure and mixed crops in Salem, Coimbatore and Tiruchira-

palli districts. It is cultivated like the 'Tinnies'. The substitution of 'Uppam' by improved strains of 'Karunganni' is recommended.

4. Nadam and Bourbon cottons

'Nadam' is an indigenous variety of perennial cotton and 'Bourbon' is a relic of the exotic cottons introduced during the East India Company days and both are grown mixed together, in the poor, light red and gravelly soils in Coimbatore and Salem districts. They occupied a small area of 1,420 acres in 1952 - '53, compared to 24,661 acres in 1939 - '40.

They are perennial cottons, which are kept on the land for 3 to 5 years and their produce forms an inferior and cheap adulterant for the better quality cottons. Their elimination by superior exotic perennial cottons like 'Moco' is being recommended. 'Moco' has a staple length of 1″ and spins up to 50's. It is suitable for the 'Nadam' and 'Bourbon' tract.

5. Westerns cotton

It is grown in the hingari (late) season from August-September to February-April in the deep black soils of the Bellary, Anantapur, Cuddappah and Kurnool districts, largely as a pure crop and as *korra-pathi* (*Setaria*-cotton) mixture in the rest of the area. Two rows of *korra* for every row of cotton is common, though in some cases, one row each of cotton and *korra* alternate. The common rotation is cotton-sorghum, but a 3 course rotation of *korra*-cotton-sorghum is also followed in some places.

Cultivation. The land is prepared by working blade harrows thrice. In *hariali* (*Cynodon pactylon* Pers.) infested lands, deep ploughing is done with heavy iron ploughs once in 3 to 5 years for the eradication of the grass. The cotton crop is sown in lines with drills. The seed rate is 10 lb. to an acre for pure crops and 4 to 7 lb. for mixed crops. In the case of the *korra-pathi* mixture, cotton seeds are sown with seed-tubes tied behind the drill and *korra* is sown through the seed hopper. The spacing between the lines is 27 to 36 inches and the plants are spaced 6 to 9 inches in the row.

The cotton crop is not manured directly, but the preceding *korra* gets an application of 4 to 6 cart-loads of cattle manure once in a way. One pair of animals is maintained for about 30 acres of land, the cattle manure produced is limited and the lands cannot be manured every year. Intercultivation is done with blade harrows thrice and the lines are weeded when necessary. *Kapas* are picked from about the beginning of March to the end of April. The yield is 250 lb. of *kapas* per acre in pure crops and about 80 lb. in mixed crops.

6. Mungari cotton

The cotton sown in the *mungari* (early) season is called the 'Mungari' cotton. It is grown in the light black and the red soils of Bellary, Anantapur and Kurnool districts from June-July to January-February. It is grown mostly as a pure crop, though it is also grown mixed with *korra* and groundnut in the ratio of 1 : 2, in a limited area. Cotton after sorghum is the common 2 course rotation.

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Cultivation. The land is ploughed once or twice and later worked with blade harrows. The drill without the seeding arrangement is sometimes worked twice and followed by blade harrows twice or thrice. Cotton is drilled at 10 lb. per acre for pure crops and at 4 to 6 lb. for mixed crops. The spacing is 26 inches between rows and 6 to 9 inches between the plants in the row. The cotton crop is not manured directly and the preceding cereal crop receives cattle manure at 4 to 6 cart-loads per acre. The crop is intercultivated twice at an interval of a fortnight, with bullock hoes. Pure crops yield 300 lb. of *kapas* from an acre and mixed crops give 80 to 100 lb.

7. Northerns cotton

This is grown in the light black, and the red soils of the Kurnool district in August-September to February-April mostly as a pure crop. It is also mixed with *korra* and groundnut sometimes. The rotations in vogue are cotton-sorghum and cotton-sorghum-groundnut for pure crops and all these crops are sown together in mixtures.

Cultivation. The land is prepared by working blade harrows 3 or 4 times, at intervals of a month. The crop is drilled like the 'Westerns'. The spacing given between the lines is 21 inches for crops sown early in the season and 18 inches for those sown late, with 6 to 12 inches between the plants in the rows. The seed rate adopted is 12 lb. per acre for pure crops and 3 to 7 lb. for mixed crops. The preceding cereal crop alone is manured with cattle manure at 5 cart-loads to an acre. Pickings commence by the middle of February and close by April. The yield is 250 to 300 lb. of *kapas* per acre in pure crops and 50 to 100 lb. in mixed crops.

8. Coconadas cotton

A type of coloured cotton, called 'Coconadas' in trade, is being grown in the Visakhapatnam, East and West Godavari, Krishna, Guntur, and Nellore districts. The lint has a reddish brown tint and is preferred for the manufacture of khaki and other coloured textiles, as it takes colour better than other cottons.

Cultivation. The 'Coconadas' are sown in June-July as a mixed crop in the early season, as both pure and mixed crops in the mid season and as a pure crop only in the late season. *Cumbu*, *tenai*, groundnut and chilli are usually mixed with it in the ratio of 2 in the case of cereals, 8 in groundnut and 14 in chilli to each part of cotton. The common rotations adopted for pure and mixed crops are the following:

1. Pure crops: Cotton-sorghum-groundnut-*tenai* or *variga*, or chilli-cotton, and

2. mixed crops: Cotton mixture-cereal or chilli. The specific rotation adopted varies slightly from place to place.

Ploughs, blade harrows and drills without the seeding attachment are worked in the field 4 to 5 times to bring about proper tilth. The crop is not manured direct, but the previous crop often receives up to 10 cart-loads of cattle manure per acre. In Guntur district, the local seed drill is used for sowing. Sowing in plough furrows and broadcasting are in vogue in the other districts. The seed rate used is 15 to 20 lb. per acre for pure crops and 6 to 9 lb. for mixed crops. The crop rows are $1\frac{1}{2}$ to 2 feet apart and the plants are spaced 6 to 9 inches apart in the rows. Intercultivation is done twice with blade

harrows in line sown crops. Broadcasted crops are hand hoed and weeded twice. Picking commences by about the beginning of March in the mid and late season crops and a fortnight earlier in the early crops. Acre yields of 350 to 500 lb. of *kapas* are obtained from pure crops and 175 to 200 lb. from mixed crops.

9. Chinna pathi

A short stapled cotton, called 'China pathi' is cultivated in parts of Visakhapatnam and Srikakulam districts, as a pure crop mostly and mixed with groundnut, chilli or gingelly sometimes. Cotton-groundnut mixture is rotated with horsegram, or horsegram-sorghum mixture. Cotton is sown in May-June in dry lands and in December-January in wet lands, after the harvest of rice.

The dry lands are ploughed 2 or 3 times and manured with cattle manure at 10 cart-loads per acre. The seeds are broadcasted at 10 to 15 lb. per acre for pure crops. In mixed crops, the ratio of cotton to groundnut is 1: 20 and the seed rate for cotton is then considerably reduced. The pure crops are hoed and weeded twice, while the mixed cotton shares the hoeing given to the associated groundnut crop. Picking *kapas* commences by September and closes by December. The yield is up to 500 lb. of *kapas* per acre in pure crops and 50 to 70 lb. in mixed crops. In wet lands, cotton is intersown amidst the standing rice crop, a little before harvest in December-January. It comes to picking in June-July.

Ginning, marketing and legislation. The process of the separation of the lint from the seeds is known as 'ginning'. Hand gins were used for separating the lint in India in early days, from time immemorial. Power

driven gins are used largely for the purpose at present. The power gins are of two main types, namely the saw gins and the roller gins. The latter are predominantly in use in India. Large ginneries have presses also and the lint obtained is pressed into bales of 392 lb. net. The lint is then sent to spinning mills, through intermediary merchants. The grower disposes of his crop as *kapas* only.

Cotton is a commercial crop of great economic importance and the quality of the produce has to be maintained at a high level, so that its level of importance can be kept up and not allowed to slide down. Legislative enactments have, therefore, been made with a view to exercise quality control and to regulate buying, selling and pressing cotton.

The grower sells his *kapas* to merchants and ginneries and the seeds from the ginneries are purchased by merchants dealing in cattle food. About 95,000 tons of cotton seed are estimated to be produced in Madras State and 40,000 tons in Andhra State. The bulk of the cotton seed is used as stock feed.

As the farmers do not retain their seed for sowing, the Agricultural Department runs special seed multiplication and distribution schemes for the several improved cotton strains released by it for general cultivation.

Certain recent trends. The production of cotton can be increased in several ways, by the use of improved strains, the adoption of intensive cultivation in the existing commercial cotton zones and the extension of the area under cotton in new areas. For instance, the irrigated black soil areas under the Tungabadra project and the red gravelly soil areas in the Bhavanisagar project are being pressed for the cultivation of Cambodia

cotton. The possibilities of cultivating the long stapled 'Sea Island' cottons along the coastal belts in South Kanara and Malabar are being explored. The utilisation of rice fallows during the off season, after 2 rice crops in wet lands, for the cultivation of cotton, is also being explored and there appears to be some scope for the development of such areas, as in the Tanjore delta. The possibilities of introducing and acclimatising superior quality exotic cottons are being worked out. The object is to fit in suitable varieties of perennial cottons like the 'Moco' in vacant sites, house compounds, etc., and produce additional cotton, without encroaching upon the area under food crops.

XII. 2 - Sunhemp (*Crotalaria juncea* Linn.)

Vernacular names : Tamil - sadambu, sanappu and shanal ; Malayalam - wuckoo ; Telugu - janumu ; Kannada - sanabu ; Hindi - san, sanai and sani.

The name 'hemp' was given originally to *Cannabis sativus,* which was grown mainly in Europe and parts of Asia, for the production of fibre. The plant goes by the name of '*ganja*' in India and produces the narcotic resin, called *ganja.* It is cultivated in India under Governmental control and license. The fibre obtained from the plant is known as Italian hemp, Hungarian hemp and so forth after the name of the country of production. It is used for cordage and sacking. Later, other fibres which had similar properties were also used for the purpose and called 'hemps', as for example, the Manilla hemp, sisal hemp, Mauritius hemp etc.

The nearest approach to the true hemp is the Indian sunhemp. It has been in use in India from very early

times and is being exported to other countries. It is used for the manufacture of ropes, cables, twine and nets, in place of the Russian hemp. The Indian sunhemp is not considered to be of satisfactory quality and does not always come up to the standards set up commercially. It is not due to any defect inherent in the fibre, but due to those present in the processing of the produce for the market.

Distribution. Sunhemp is cultivated throughout India, for its fibre, fodder and green manure, and largely in Bombay, Madras, Andhra, Madhya Pradesh and Berar. It is grown extensively in Andhra Desa, particularly in the uplands of Guntur, Krishna and Godavari districts mixed with other crops and as a pure crop in wet lands after the harvest of rice, with the moisture in the soil. Its cultivation as a green manure crop has spread to the whole of South India. It is grown for fibre in about 60,000 acres in Andhra and 1,000 acres in Madras.

Adaptation. Sunhemp comes up very well in the tropical plains. It does not thrive in elevations over 3,000 feet above sea level. It makes vigorous growth when sown from March to August. Seeds set satisfactorily, when the crop is sown from June to August and very poorly when sown between November and April. It makes good growth in light, well - drained soils, when the rains are favourably distributed, or when irrigations are provided at suitable intervals. The crop is able to stand heavy rains, only when the soil is well-drained, as along the West Coast. On heavy and low lying lands, it makes little growth and the fibre produced is coarse. It can be sown as a green manure crop in all soils, but the growth is not satisfactory in heavy as in the light soils.

Varieties. There are many varieties of sunhemp and they are generally named after the tracts, where they are grown. Some are very early, maturing in 45 days, while at the other end are certain varieties which take $5\frac{1}{2}$ months to mature. There are also wide variations in the habit of growth, size of plants, size of leaves and other characters. Fibre types have a tall non-branching habit combined with stout stem, thick bark and ability to shed the leaves when the crop is mature. Green manure and fodder varieties have herbaceous stems and plenty of leaf.

Rotations. In the wet lands of Tirunelveli, sunhemp often precedes rice. In the Godavari uplands, it is one of the crops in the 3 course, 3 year rotation, chilli or tobacco-sunhemp-rice (rain fed). It is considered that there is improvement in the yield of fibre, when sunhemp follows tobacco or chilli and improvement in quality at the expense of the yield, when it follows rice. Heavy manuring promotes vigorous growth and at the same time coarseness in the fibre. Poor soils are, however, manured with cattle manure at 8 to 10 cart-loads per acre, while in rich soils, sunhemp is grown after exhausting crops like sorghum. Thus medium fertility would appear to be the best for the production of fibre.

Cultivation. The land is prepared thoroughly with pre-monsoon showers. The thoroughness of preparation is of assistance in promoting quick and vigorous growth so much desired in fibre crops. Sunhemp seeds are sown at 40 to 100 lb. to an acre and covered by ploughing. Low seed rates are used in poor soils and heavy rates in rich soils. Heavy seeding discourages branching and induces a straight habit of growth. The sowings are done with

the north-east monsoon in September-October and sometimes in February, after the soil is thoroughly soaked by rains. The crop makes vigorous growth and does not require any after-cultivation. In Godavari district, however, it is subject to the incidence of the weed *Ipomoea hispida* (R & S., called *pala kada* and *pala jammi* locally, which interferes with the extraction of the fibre, and the crop is therefore weeded thoroughly in the early stages. Sunhemp is grown under rain fed conditions, ordinarily. It is only in parts of Tirunelveli that it is treated as an irrigated crop. The sowings are done in dry soils, and they are irrigated afterwards.

The harvest of the fibre crop can be done, when it is in various stages of maturity. For instance, the harvest is done when the pods are just setting in Godavari and when the pods dry up in South Kanara and Tirunelveli. Immature crops give clean white fibres, fine in texture and of little strength. The fibre from mature crops is coarse and strong. The stage at which the crop is cut depends upon the market demand and the use to which the fibre is put. Green plants produce green tinted fibre, while dry plants give a white fibre.

Harvest. The crop is cut close to the ground and left as sheaves in the field, when the leaves are shed. The tops of immature crops are cut and used for feeding cattle and the pods are stripped from mature crops, for use as seed. The plants are then tied into small bundles and steeped in water for retting. In Tirunelveli and South Kanara, the mature crops are cut, dried thoroughly, stacked and taken for retting later. Dry stems ret quickly. Stacking dry plants is not always convenient and farmers prefer to ret the green stems and extract the

fibre immediately after harvest. Where water is, however, not available for retting at the time, the produce has to be dried, kept stacked and retted when water becomes available.

Retting consists of steeping the plants in tanks, ponds, channels and even in specially prepared wet fields, as in parts of Godavari. Here, low lying wet lands near sunhemp fields are puddled and kept stagnated with water. Sunhemp plants are tied into bundles and laid side by side, immersed in muddy water by weighting with mud. The fibre strands get loosened from the stem in 3 days and they are then taken out for stripping.

In Ganjam, a number of small bundles are tied together and the big bundles so formed are stooked in water, with the bundles resting against one another. About two-thirds of the base of the stem alone is kept immersed in water to start with. The bundles are laid flat after a day and the entire bundle is then immersed in water. This enables the entire bark to get softened evenly, from the tip to the base. When dry stalks are retted, the bundles are immersed in water for about 5 days and then dried in the sun for 3 days, before taking up the extraction of the fibre.

Extraction of fibre. A bunch of stems is held in the hand and bent, so as to break the stems at about 10 inches from the base, without damaging the bark. The small pieces of broken stem at the base are pulled out one by one, leaving the surrounding bark hanging loosely. This is held in one hand, and the other hand is inserted between the bark and the remaining stem and passed from the base to the tip of the stems. This separates the bark from the stems. The small bunches of stems are suppor-

ted on both the knees, when the bark is being separated. The separated barks are then rinsed in water, when the binding soft tissues are washed off, leaving behind clean fibre. The fibre strands are then dried in the sun knotted at the upper end and kept twisted up. Each twist contains a bunch of fibres, which can be held conveniently in the hand.

In some places, the retted stalks are struck against stones, when the stems get broken into a number of small pieces and get detached from the fibres. These are rinsed in water, to get the fibres freed of the broken stems. The cleaned fibre is hung on racks and dried.

Hackling or combing. Sunhemp fibre is exported, mostly in the raw state. In some cases, the fibres are combed by hand or hackled, for separating the short fibres present along with the long fibres. The separated short fibres go by the name of 'tow'. The tow is used for making cordage and rough twine, and also for packing seams in ship decks, and making them water-tight. The fibre, cleaned of the tow, fetches good prices in foreign markets.

Baling. The cleaned fibre is packed in bales for export. The fibre is plaited and the plaited strands are made into bundles and baled. The bales are then put in presses and each ton of the compressed fibre occupies about 50 cubic feet. The fibre yield ranges from 600 to 1,000 lb. per acre and this is produced from 3 to 5 tons of dry stalks.

Fibre characteristics. The sunhemp fibre of commerce consists of ribbon-like strands, 4 to 5 feet long. The individual fibres have bulbous ends, which are thick and rounded. They are slightly lignified and the best grades

resemble the Russian hemp in appearance, though not so strong. They do not get decayed in water so quickly as the Russian hemp and both are valued alike in the importing markets.

Certain studies made of sunhemp fibres at the agricultural station, Samalkota in East Godavari indicate that,

1. early varieties produce short fibres, while long duration varieties produce long fibres,

2. a seed rate of 75 lb. to an acre may be the optimum for fibre crops,

3. the crop gives the highest yield of fibre, when cut at the full bloom stage,

4. manuring the crop in excess of 5 tons of cattle manure to an acre is unnecessary,

5. retting the stalks after wilting for about 3 days is better than retting green, immediatly after harvest,

6. drying the stalks and retting them after 2 or 3 months lowers the yield and quality of the fibre,

7. the stalks ret more rapidly in muddy water than in clear water, though the latter gives a whiter fibre,

8. the stalks ret more quickly in still water than in running water, taking 2 to 2½ days in muddy still water and 5 days in clear running water, and

9. combing lowers the weight of fibre by 3 to 4 per cent.

Seed production. The fields are prepared by ploughing and sunhemp seeds are sown at 20 to 25 lb. to the acre, in May-June. Weeding is done when needed. The tops are cut when the pods are mature, dried in the sun and threshed by flailing with bent sticks. Seed yields range

from 400 to 700 lb. per acre. The stalks left in the field are cut and used for extraction of fibre.

XII. 3 - Bimlipatam jute (*Hibiscus cannabinus* Linn.)

Vernacular names: Tamil - pulichai and puli manchi; Telugu - gogu; Kannada - pundi; Hindi - patwa.

Bimlipatam jute, also called the 'Bombay hemp', or 'mesta' is an important fibre crop in Andhra and is grown throughout Madras and Andhra States. It is cultivated as a rain fed crop in large areas in the Northern Circars. It is sown on the bunds of irrigation channels and in small patches in garden lands in Tamil Nad, mainly for use in the farm. It is stronger than Bengal jute, but not so flexible and soft.

Gogu is said to have been introduced from South Africa and it is grown in India from time immemorial. It is grown mixed with most cereals in dry lands along the Circars coast and as a pure crop in Guntur, Visakhapatnam and Srikakulam only. The area under the crop is about 1 lakh acres in Andhra, and 2,000 acres in Madras. Srikakulam alone has about 95,000 acres.

There are many varieties of *gogu* with considerable variation in the lobing of the leaves and the pigmentation of the plants. Two main types are recognised in Andhra, namely 'manchi' or 'desi' *gogu* used for chutney and for the extraction of fibre, comprising *H. cannabinus* Linn., and 'pulla gogu' used for chutney only, comprising *H. subdariffa* Linn and *H. furcatus* L. *H. supdariffa* goes by the name of 'Roselle' in other countries. A variety of this species, called *H. subdariffa* var. *altissima*, introduced from North India in recent years, is becoming very

popular as a fibre crop. It has a straight habit of growth and grows tall.

Cultivation. *Gogu* is sown with the commencement of the south-west monsoon in all kinds of soils, in black soils as at Guntur, and in wet and dry lands as at Srikakulam and Visakhapatnam. The land is prepared as for other dry crops. Manuring is not common, though it is done sometimes by individual farmers. Seeds are sown at 25 to 30 lb. to an acre. One or two hoeings are given and the leaves are picked, when they are tender for use at home. The plants flower in 3 to 3½ months and are harvested before the seeds mature. Water is let into wet lands and the plants are pulled out with the roots. The tender top portions are cut and the green plants are made into small bundles and steeped in water for retting. They are kept in a vertical position to start with and laid flat after a few days to bring about uniform retting from the base to the top. Retting takes 15 to 20 days and the fibre is extracted as in the case of sunhemp. The yield of fibre is about 1,000 lb. in the Northern Circars and 700 to 800 lb. per acre in other places. The ratio of the dry fibre to the green plants is about 4 per cent and to dry plants 16 per cent.

XII. 4 - Agave (*Agave americana* Linn.)

Vernacular names: Tamil - kathalai; Malayalam - wakkuchan; Telugu - kalabanda; Kannada - kattale; Hindi- rakkaspatte.

The agave plant was introduced from America. It is a hardy, vigorous xerophyte which can be cultivated in waste lands, along fences, embankments and the sides of railway lines. It is grown as a hedge plant, round fields to

serve as fence against castle trespass. It is established by planting suckers produced at the base of grown-up plants. The suckers are planted in small pits, 8 feet apart each way, in regular plantations. The interspace is cultivated once in a way. The leaves are cut from the plants from the second year from the base upward, leaving a few tender leaves at the top. The leaves are passed through stripping machines and are subject to pressing and teasing, when the fibres get separated. The fibres are clean, white and silky in appearance. The leaves are also split into narrow ribbons, dried and used for binding harvested crops and for thatching houses. The green narrow ribbons of leaves can be retted and the fibre extracted by scraping with dull edged knives and removing the decomposed soft tissues. The fibre obtained by retting is dull coloured.

The agave plants flower in 12 to 15 years. A big inflorescence - like head is produced, where bulbils are formed, and not fruits as in other plants. The agave then dies out. Bulbils are miniature live plants, which can be used for propagation and which form roots after being planted.

XII. 5. **Bengal jute** (*Corchorus olitorius* Linn.) and (*C. capsularis* Linn.)

Bengal jute is known as '*goni*' in Tamil and Kannada and 'Kosta' and 'Narcha' in Hindi. It is cultivated mostly in Bengal and Assam. It requires a heavy rain-fall of about 60 inches and a hot climate. It is resistant to drought to a small extent in the early stages and tolerates stagnation of water, after it attains a height of 2 feet. It comes up well in clayey and loamy soils. The

land is prepared thoroughly and seeds are sown at 8 to 10 lb. per acre in March-April. The plants grow to about 8 feet and are in the small pod stage in the course of 5 months, when they are harvested. They are steeped in water and the fibre is extracted as in sunhemp. The fibre is spun into yarn and gunny fabrics are made from it in power mills.

Jute can be grown in other regions also, but attempts to cultivate it has not met with commercial success outside Bengal and Assam.

XII. 6. Flax (*Linum usitatissimum* Linn.)

Flax is only a variety of linseed, which is grown for the production of fibre in Europe and America. A temperate climate favours the production of superior quality flax. Attempts made to grow flax in India have not been successful. The principle underlying the process of extraction of fibre is the same as with sunhemp. The fibre has to be loosened from the stem and separated. Flax can be retted like other fibres. In America, the flax stems are exposed to sun and dew alternately, for softening the bark and facilitating its separation. This is called 'dew-retting'. The fibre gets darkened during dew-retting, but it is clean and free of mud and other impurities.

The flax fibre is extremely fine and it is used for making textile fabrics of superior quality and durability. The famous Irish linens are made of flax fibre.

XII. 7. Coconut fibre or coir

The word 'coir' is derived from the Tamil word '*kaiaru*', which means rope. It is obtained from coconut

husk. Coir and coir products like yarn, matting etc., have a firm export market and a good local demand. The extraction of the fibre is done chiefly in Malabar and Travancore-Cochin and to a negligible extent in Amalapuram of the Godavari district.

Fresh coconut husk, obtained when coconuts are dehusked, is retted in river beds and in the coastal backwaters in Malabar for 6 to 8 months. The retted husk is teased by striking with small wooden mallets, when the fibres get separated from the surrounding pith. The fibres are then washed free of pith and dried in the sun. The husks from about 5,000 medium sized nuts produce a ton of fibre.

XII. 8. Banana fibre

The leaf sheaths of banana are fibrous and the fibre is extracted from them in certain places. The soft tissues in the sheath are removed by scraping with blunt knives, and applying a light pressure at the time. The fibre can be spun and woven into fabrics which have a silk-like finish. A variety of banana called *Musa textilis* Nee. is specially grown for the production of fibre in Manilla. It is a vigorous growing species and the fibre obtained is called 'Manilla hemp'. It is used for making ropes and cords, for use with machinery. The rope wound round the wynch drums of tube - well boring machines is made of Manilla hemp. It has the required strength and flexibility. It is about the strongest vegetable fibre known.

CHAPTER XIII

NARCOTICS

XIII. 1. Tobacco (*Nicotiana tabacum* Linn.)

Vernacular names. Tamil and Malayalam - pugayelai; Telugu - pogakku; Kannada - hoge soppu; Hindi - tamakku.

Origin and importance. The tobacco plant is a native of tropical America and is sometimes referred to as the aromatic weed. It was introduced into Europe by one Jean Nicot, a French Ambassador towards the close of the 16th century and the genus is named after him. It was introduced into India by the beginning of the 17th century. It is now grown all over India, the various tropical regions of the world, and even in the subtropics. It is used for providing exhilaration and a general pleasant feeling, as a smoke in the form of cigarette, cigar, pipe, *beedi* and *hookah,* as a quid either alone or with betel leaves and as snuff. By far its largest use in the early years was as quid in the tropics and as cigar in the European countries. The habit of smoking cigarette has now become so common all over the world and among all classes of people, that the use of tobacco as cigarette takes precedence over other forms. The cigarette is a development of the last 100 years alone.

Since the use of tobacco has become universal, world trade of the various types of tobacco has developed and large areas are devoted to tobacco all over the world; U. S. A. and India are the two largest tobacco producing

countries. It is an important crop in China, Java, Sumatra and Rhodesia. Canada, Central America, Mexico, the West Indies, the Guianas, the East Indies, Indo-China, Japan, Persia, Southern Russia and large parts of Africa produce tobacco in large quantities.

The tobacco produced in U. S. A. is light in colour and is used largely in the manufacture of cigarettes. All types of tobacco are being produced in India—light coloured tobacco for cigarettes and tobacco of various kinds for

Name of country		Extent in acres	Production of tobacco
		(1,000s)	in 1,000 lb.
North America		2,192	2,686,173
	Canada	92	139,719
	United States	1,773	2,254,855
Europe		750	641,458
U. S. S. R.	**(old figures)**	490	525,000
Asia		3,537	2,786,260
	Turkey	320	200,619
	Burma	135	100,800
	Ceylon	15	8,300
	China	1,320	1,317,065
	India	775	520,000
	Pakistan	170	150,000
	Japan	136	209,990
	Java group	389	124,484
South America		589	434,625
	Brazil	405	262,832
Africa		473	259,220
	Rhodesia	207	120,750
Oceania		12	12,644
World Total		8,073	7,220,380

Source: *U, S. D. A, Agrl. Statistics*, 1953 - '54.

chewing, making *beedies* etc. The cultivation of cigarette tobacco in India is a recent development. The area under this type was only a few acres in the early twenties, round about Guntur, while it is about 1·34 lakhs acres now. It has also spread to the neighbouring districts and Mysore. The quality desired in cigarette tobacco is not attained satisfactorily elsewhere in India.

Distribution. The extent of cultivation and production of tobacco in the several countries of the world during the year 1952, were as in page 483.

The U. S. A. leads in acreage and production of tobacco, followed by China and India. In India, the tobacco crop is largely concentrated in Andhra and Bombay, both in the hot tropics. The extent of cultivation of tobacco in 1953-'54 in the Indian States are furnished below:

Name of State	Extent in acres (1,000s)	Production of tobacco in 1,000 lb.
1. Andhra	307	97
2. Assam	22	7
3. Bihar	30	10
4. Bombay	273	65
5. Hyderabad	43	11
6. Madras	49	28
7. Madhya Pradesh	9	2
8. Mysore	29	2
9. Orissa	11	3
10. East Punjab	6	2
11. Uttar Pradesh	24	6
12. West Bengal	39	11
13. Other States	28	6
All-India Total	870	250

Source: *'Agrl. Situation in India'*, Aug. '54, pp. 294.

The normal extent of tobacco cultivation in Madras and Andhra and the area under 'Virginia' tobacco in important districts during the year 1952 - '53, are given below.

Madras		Andhra		
Name of district	Extent in acres (Normal)	Name of district	Extent in acres (Normal)	Extent under 'Virginia' in 1952 - '53 (acres)
South Arcot	1,440	Srikakulam }	14,380	
North Arcot	960	Visakhapatnam }		
Salem	4,110	East Godavari	28,410	23,045
Coimbatore	27,810	West Godavari	32,370	23,657
Tiruchirapalli	2,590	Krishna	25,300	21,945
Tanjore	1,470	Guntur	165,430	133,738
Madurai	5,330	Kurnool	6,820	
Ramanathapuram	790	Anantapur	2,660	
Tirunelveli	290	Cuddapah	870	
Malabar	40	Nellore	2,890	
South Kanara	1,550	Chittoor	570	418
Nilgiris	10			
Total-Madras	46,390	Total-Andhra	279,780	202,803

Source: *Madras Government, Season and Crop Report of the Madras State for the year* 1952 – '53, 1955.

The cultivation of tobacco is prominent in Coimbatore and the Northern Circars districts, with the cigarette type of 'Virginia' tobacco confined largely to Godavari, Krishna and Guntur.

Adaptation. Tobacco is essentially a crop of the tropics, where it is cultivated during the cold season, when the minimum temperature ranges from 58° to 70° F. It is also cultivated in the subtropics, in small areas during summer. Tobacco grown under a mild climate is devoid of its full aroma, flavour and strength. A warm

dry climate and bright sunlight during the period of maturity favour the development of gums and resins on the leaf, which give it a rich flavour. Rains received during the period of maturity wash out the gums and resins on the leaf and the final quality is impaired. The crop does not tolerate heavy rains and stagnation of water.

In the Guntur tract, the 'Virginia' and the local tobacco are cultivated in large areas, under rain fed conditions. There is an average rainfall of 28 inches from June to November, and the period from December to February, when the crop is maturing, may not have more than 0·5 inch of rain per month. The soil is of the black cotton soil type, which retains moisture very well and is able to bring the crops planted in October to maturity. The climate is cool and dry, and the sun is bright during the period. All these favour the growth of tobacco and account for the superior quality of the tobacco produced and the large acreage under the crop.

Tobacco requires for its proper growth and development a well - drained soil, which can retain sufficient moisture. The capacity to hold moisture assumes special importance in regions of medium rainfall, when the crop is cultivated under rain fed conditions. It is not so important, where supplementary irrigation is provided. Drainage is particularly necessary, where the rainfall is generous. Red loamy soils are very suitable for tobacco, though it is grown in heavy as well as light soils. It is cultivated in the clays and clay loams of the Guntur district and in coastal sandy soils, as in parts of the West Coast and Ceylon.

Tobacco leaves produced on heavy soils are generally thick, coarse, heavy bodied and strong. On the other hand, those grown on light and poor soils are thin and mild.

Varieties. Though the cultivation of tobacco is spread all over India, more than half the acreage is confined to the following regions :

North Bihar	- *hookah* tobacco,
North Bengal	- *hookah* tobacco,
Guzerat	- *beedi* tobacco,
South Bombay	- *beedi* tobacco, and
N. Circars in Andhra	- cigarette tobacco.

There are a number of species of *Nicotiana,* which contain the alkaloid 'nicotine', which gives tobacco its distinctive charcteristics. Most cultivated tobaccos are of the species *tabacum* Linn., though the species *rustica* Linn. and *persica* are also under cultivation. *N. rustica* has leaves with a high nicotine content, going up to 8 per cent and it is under cultivation in large areas in North India, beyond the Tropic of Cancer, with also small areas under the *tabacum* species. The *rustica* species plants produce light yellow coloured flowers, while the *tabacums* produce white or light pink coloured flowers. *N. tabacum* alone is under general cultivation in South India and most parts of the world. World trade is with *N. tabacum* only. It is a delicate species, when compared to others and produces leaves of varying quality, with low nicotine content of 2 to 3·5 per cent, agreeable mildness and pleasing flavour, preferred by consumers ordinarily.

The commercial and field classification of tobacco into varieties is largely based on the use for which the

leaf is suitable. Thus, it is divided into (1) the cigarette tobacco (Virginia and certain others), (2) cigar tobacco, with the sub-classification into (a) filler, (b) binder and (c) wrapper tobacco, (3) *beedi* tobacco, (4) quid tobacco, (5) snuff tobacco and (6) *hookah* tobacco. The various characteristics, which influence quality and distinguish the several types are the following :

1. *Colour.* This is an important character in tobacco, which clearly marks out the quality in each type. The depth of colour is more or less indicative of the strength of the tobacco. Dark leaves are generally strong and are used as quid, *beedi,* or as pipe tobacco. Light to dark brown coloured leaves are preferred for making cigars. The high priced mild cigars are made with light brown leaves. *Beedies* are made with orange or greenish brown leaves that are not cured properly, and dark brown leaves are mixed with them to furnish the required strength. Cigarette leaves are bright lemon yellow in colour and those that have brown spots are used for making cheap cigarettes. Colour is not so important for snuff and *hookah* tobaccos. Light brown colour in quid tobacco is preferred in Bombay, dark brown in Madras and a very dark colour in Travancore-Cochin.

2. *Texture.* This also is associated with the strength of tobacco to an extent. Thick bodied leaves have a high nicotine content, in general and are stronger than the thinner types of leaves. The cigarette leaf is fairly thin, fine and silky to the feel, but not too thin and papery. A certain body is also required for giving the material strength to withstand cutting and shredding during manufacture and to prevent it from becoming powdery

during the process. Medium thickness and pliability of the leaf characterise pipe tobacco. The cigar fillers are medium to heavy in texture. Thick leaves, which are not coarse, are suitable for *beedies.* Choice quid tobacco is of medium thickness. Scented quid tobacco is, however, made with thick leaves. Thick and coarse types are used for *hookah,* where the smoke is drawn through water and made cool, mild and mellow.

3. *Size.* The following sizes of leaf are preferred in the various types :

a. cigarette leaves - 12 to 18 inches long and 6 to 9 inches wide,

b. cigar wrapper - 24 inches long and 11 inches wide and

c. others - size is not a consideration.

4. *Blemishes.* Diseased patches and damage of the leaf are defects in tobacco used for making cigars and cigarettes. They are not so objectionable in the other types.

5. *Smoking qualities.*

a. Strength. This is the most important quality desired in smoking. Cigarettes are mild and are made with leaves, which have a low nicotine content of 0·5 to 2·5 per cent. The nicotine content is higher in pipe tobacco. *Beedies* are made with leaves, which have a nicotine content of 2·5 to 3·5 per cent. Quid tobacco is as strong as *beedi* tobacco. *Hookah* tobacco is very strong.

b. Burning quality. Smoking tobacco has to burn slowly, regularly and continuously. When a leaf is lighted with a match stick, the burning spot spreads out

slowly and the extent of spread of the burnt area is an index of the burning quality in cigars. The whiteness of the ash is an index of the burning quality. The burnt ash sticks to the cigar till flicked, with good quality leaf and it does not drop down by itself.

6. *Aroma and flavour.* These are properties which cannot be defined precisely. Aroma is sweet smell. The smell of tobacco has to be pleasant and free of acridity, bitterness and pungency. Flavour is the fragrance which characterises the particular produce and each type of tobacco leaf should have its characteristic flavour.

Rotations. Tobacco is generally cultivated after cereal crops, but not after leguminous crops, which leave the land rich in nitrogen and promote rank growth in tobacco. This leads to a fall in the quality of the leaf produced. In Guntur and Godavari regions, sorghum or dry land rice is followed by tobacco and later by chilli or *variga.* Tobacco is sometimes grown repeatedly on the same land without any rotation, particularly in small holdings. This encourages the spread of *Orabanche nicotiana,* a root parasite, which gets attached to the roots of tobacco and affects the growth of the tobacco crop adversely. In the Coimbatore region, sorghum, Cambodia cotton, *ragi*, and tobacco form a four course 2-year rotation in garden lands. In Sivapuri and Vedaranyam, tobacco is grown repeatedly on the same land, without any crop in between, with intensive cultivation and manuring. It is not grown mixed with other crops.

Season. Tobacco nurseries are sown in South India from the beginning of August to the end of September. The seedlings are transplanted in the field when they are 6 weeks old, both in dry and garden lands, and the

transplanted crop is in the field for 4 months, from October to February. In Mysore, tobacco is raised in 2 seasons, from January to June and from October to March.

Preparatory cultivation. The Godavari and Krishna *lankas* are prepared after the seasonal flushes in the rivers subside. They are overgrown with grass, which is first grazed with cattle. Later, they are ploughed up and brought to condition for transplanting tobacco. In Guntur, the lands are ploughed twice in June and later at close intervals from September till transplantation is taken up in October. Garden land areas are ploughed repeatedly and brought to good tilth. In Sivapuri, the land is dug with spades to a depth of about 1 foot. There is also the practice of transplanting tobacco in *ragi* stubbles, without any preparation of the land at Coimbatore. The inter-row spaces are ploughed later, or hoed deep with spades.

Manuring. Tobacco is generally cultivated in lands, which are maintained at a satisfactory level of fertility by manuring. Further, the tobacco crop is heavily manured. With regard to garden lands, sheep are penned at about 3,000 per acre at Coimbatore. Cattle manure is applied at 25 to 30 cart-loads per acre in the Dindigul region and town sweepings are applied at 100 cart-loads per acre at Sivapuri, where tobacco is grown without any rotation. It is considered that cattle manure and *natham mannu* (the crumbly earth that collects at the foot of mud walls in villages) improve the quality of the quid tobacco. Cattle manure is applied at the time of the preparation of the land and village earth as a top dressing. The latter contains some potassium nitrate.

Virginia tobacco grown under rain fed conditions receives 10 cart-loads of cattle manure, 25 to 40 lb. of ammonium sulphate, 50 lb. of potassium sulphate and 400 lb. of superphosphate per acre. These are applied in August, two months before planting tobacco, when the weather is clear and ploughed in.

Nurseries. Tobacco seeds are very small in size, the seedlings that emerge from them are very delicate and they require careful nursing in the early stages. Tobacco seedlings have, therefore, to be raised in nurseries and tobacco cannot be sown directly in the field like other crops. The nurseries are located in high level areas, which can be drained easily during rainy weather. Tobacco seedlings are raised in the Bapatla region, in extremely sandy soils. The seed-beds are manured heavily with cattle manure and ammonium sulphate, and the seedlings raised are distributed for transplantation over wide dry land areas in Guntur district, where facilities are not available for raising nurseries. Nurseries are located by the side of irrigation sources in other tracts. They are ploughed repeatedly and brought to good tilth, manured with cattle manure, rather heavily at 100 cart-loads per acre. Later, long narrow beds, 3 to 4 feet wide, are formed and drainage channels are provided in between rows of beds. The channels are lower in level than the beds and facilitate rain water draining away easily. They are also used as irrigation channels, with water ponded to raise the level and facilitate the flow of water from the channels to the beds. Space is provided between the beds to serve as pathway for people engaged in watering and weeding the nurseries. Tobacco is often subject to wilt or the 'damping-off' diseases, caused by fungal organisms in the soil. Overcrowding of the seedlings in

the beds and insufficient aeration of the soil are predisposing factors contributing to the incidence of the disease. Nurseries may advantageously be sterilised by burning twigs, dry weeds and brush wood spread on the surface. Wilt can later be controlled by spraying the young seedlings with Bordeaux mixture 4 : 4 : 50 (lime - copper sulphate - water) at 10 gallons per cent of nursery. Seed borne infections like 'Black shank' can be controlled by steeping the seeds preliminarily for a short time, in silver nitrate solution at a strength of 0·1 per cent and washing them thoroughly before sowing.

Tobacco seeds are sown in nurseries at 1 ounce per cent of nursery ordinarily and seedlings from a cent of nursery are transplanted over an acre. The seed rate is rather high and 1 tola (2/5th of an ounce) of seed per cent will suffice. The seed is mixed with fine sand for increasing the bulk and facilitating the even distribution of the seed over the nursery. Uniform distribution of the seed can be secured by dividing the seed into 2 lots and covering the nursery length and breadthwise respectively. The seeds are imbedded in the soil by pressing the surface of the nursery with the palm of the hand. If the seeds are covered with soil as with other seeds, they do not germinate. In the Godavari region, the seeds are soaked in water for a day and hung up in a fold of muslin cloth. They are kept moist by sprinkling water over the cloth at intervals. They germinate in about 3 days and are then sown in seed-beds. Dry seeds alone are sown in other regions.

The seed-beds are moistened by sprinkling water with rose can, 1 to 4 times a day, depending upon the weather conditions. They are protected against the sun

by covering with coconut fronds, brushwood etc. and this prevents the seeds from getting dried up. The cover is removed after the seeds germinate. The seed-beds are kept shaded with temporary thatch very rarely. The seeds germinate in 7 or 8 days and the seed-beds are then sprinkled with water once a day, and irrigated once in 3 or 4 days after about 10 days of growth.

Weeds that spring up on the nurseries are hand picked 2 or 3 times. The seedlings put out 5 or 6 leaves by about 6 weeks, when they can be transplanted. The seed-beds are moistened and robust seedlings alone are pulled out. Small seedlings are left behind in the nursery for making further growth and they are lifted later, when required.

Failure of tobacco seedlings in the nursery is common and nurseries are, therefore, raised in batches at intervals of a fortnight as a safeguard. If all the batches of nurseries come up well, seedlings will be surplus over requirements. The cost of raising extra seedlings is only a small part of the total expenditure and it is worthwhile producing surplus seedlings.

Transplanting. Tobacco seedlings are generally transplanted in the evenings during cloudy weather, when weather conditions permit. If seedlings are transplanted in bright weather, they lose their turgidity and do not establish easily. In the rain fed areas of the Guntur region, tobacco seedlings are check planted at 2 seedlings per hole, 2½ feet apart each way, as with chilli. The transplanted seedlings are not protected in any way here. In certain regions, small twigs with leaves are planted with tobacco seedlings to provide some slight shade, till the seedlings establish.

In Tamil Nad, tobacco is grown mostly under irrigation. Water is let into furrows and tobacco seedlings are planted at one seedling per hole, in the wet mud, on the sides of the furrows. The spacing given between the plants varies from region to region. The seedlings are planted 1½ feet apart at Dindigul, 2 feet apart at Coimbatore and 2½ feet apart in the Northern Circars and 19,000, 14,000 and 11,000 seedlings respectively are required for transplanting an acre. The same spacing is given for both irrigated and rain fed tobacco. The plants make vigorous growth with wide spacing and produce large sized, thick leaves. With narrow spacing, the leaves produced are small in size and thin.

After cultivation. In Tamil Nad, the tobacco crops are hand-hoed twice and hoed with spades later, and slightly earthed-up, after the plants start growing vigorously. The tobacco, planted in the stubbles of the previous *ragi* crop without any preparatory cultivation is hoed deeper. Where the plants are vigorous and grown up at the time of hoeing with spades, as at Sivapuri, the leaves are brought close together, secured with straw twists and released later. At Guntur, the inter row spaces are first worked with drills without the seeding arrangement, and later with bullock hoes.

Topping. The top portion of the plant is removed in the quid and cigar types of tobacco, when about 50 per cent of the plants produce flower heads. This is called 'topping'. A few plants are left without topping, for the production of seed. Topping leaves behind a certain number of leaves alone on the plants and this number varies from tract to tract, being 12 to 15 at Sivapuri and Dindigul, and 8 to 10 only at Coimbatore. These leaves

increase in size, develop a thick body and improve in quality by topping. Topping is not done for cigarette tobacco, under the wrong impression that topping will induce the production of greener leaves, and lower the quality of the produce. Experiments at Rajahmundry and Guntur show that topping plants with greenish yellow leaves improves the body and size of leaves and increases the yield by 10-15 per cent, without affecting the quality. Dark green leaved plants should not, however, be topped.

Desuckering. When tobacco plants are topped, the axillary buds become active and produce new shoots, which are pinched off at frequent intervals. This is called 'desuckering'. It has been recently noted at the Tobacco Research Station, Rajahmundry, that if the top axillary buds are touched with coconut oil after topping, they do not grow and put out new shoots. If the axillary buds are allowed to develop, they take nutrition from the plants and the leaves on the main stem do not develop to the required extent and quality. The maturity of the leaves is also delayed and further, the cured leaves tend to be slightly bitter.

Irrigation. Tobacco crops are irrigated once in 3 or 4 days in the early stages of growth and once a week later. The water used for irrigation has a large influence on the quality of the leaves. When it is brackish, the leaves develop a good burning quality and flavour. Certain areas in Dindigul of the Madurai district and Sivapuri of the South Arcot district have brackish underground water, which is used for irrigating tobacco. The tobacco leaves produced there are of high quality and far superior to those produced in the neighbourhood, where the underground water is comparatively sweet. It is considered that the potash salts present in the irrigation water are

responsible for the superiority of the leaves produced. Dindigul tobacco is prized as being suitable for quality cigars, which burn evenly, and are mild and fragrant. Sivapuri tobacco is the best quid tobacco in South India.

Harvest. The tobacco crop is harvested at different stages, depending upon the type of tobacco. The signs of maturity of tobacco leaves, particularly of the chewing type, are the following :

1. The leaves turn pale green, with yellowish coloured spots here and there. There is also a crinkling of the leaf surface.

2. The leaves feel sticky to the touch, due to the formation of gums and resins on the surface. Rains received during the time of maturity of the leaves wash off the gums and resins, and the quality is lowered thereby.

3. The leaves that were pliable originally, tend to get broken when handled, and

4. In the Sivapuri chewing tobacco, round brown spots, called 'mohar marks', are developed.

Tobacco is harvested in the evenings generally, when the leaves are not liable to get broken so easily as in the mornings. Further, if the harvest is done in the morning, the leaves are dewy and get soiled on contacting the earth. The plants are cut at the base in Tamil Nad and Kurnool. In Godavari *lankas*, the plants are cut into as many sections as there are leaves, with 1 to 2 inches of the main stem attached to each leaf.

Curing. The quality of tobacco is influenced to a great extent by the curing of the harvested leaf, and considerable skill and experience in curing are required.

The curing is done in various ways in the different tracts to suit the type of tobacco and the demand of the market. It is essentially a process of drying the leaf, with regulated fermentation during the period of drying. Bacteria play an important part in it. The fermentation is influenced by the carbohydrates, sugars and moisture present in the leaves, the temperature during curing and the aeration provided. If the leaves are dried straightaway, they get brittle and lack in burning quality, aroma, flavour, taste and pliability, desired in the final products, and the ash left behind after burning is blackish grey in colour. The tobacco and the smoke are also bitter. When the leaves are cured properly, they are yellow to brown in colour, with a silky texture and a pliable elastic web, and they give a pleasant characteristic smoke of a light blue colour and a white coloured ash. Though proper curing is necessary, it cannot by itself produce quality in inferior leaf, even with skilful manipulation. The various methods of curing can be divided into the following major types:

1. Flue curing of cigarette tobacco,
2. rack curing of cigar and quid tobacco, and
3. pit curing of quid tobacco.

1. *Flue curing.* This is the method adopted for the production of cigarette tobacco. The curing of the leaf is done in barns, where the temperature, moisture and aeration are regulated and kept under control. The barns are rectangular structures, provided with galvanised iron roofing. They are constructed in 2 sizes at Guntur, 16′ x 16′ x 16′ and 20′ x 20′ x 20′, suitable for curing the produce from 15 and 20 acres respectively, at a time. They are provided with one or two furnaces and heated

air is passed through metal flues for raising the temperature inside the barn. The temperature and the flow of hot air through the flues are regulated by shutters, which can be closed and the hot air kept off from the barns. Ventilators are provided on the sides of barns, for regulating the aeration, temperature and the moisture of the atmosphere inside.

The 'Virginia' tobacco leaves turn pale and light yellow as they mature, from the base upward and they are harvested in stages as they get ready. The harvest is done ordinarily in 3 stages. The harvested leaves are cured in barns and the curing of each lot takes 5 to 6 days.

The leaves are strung on thin bamboo poles, 5 feet long, keeping their two ends free. A kind of simple looping with strings keeps the leaves hanging from both the sides of the poles. Each loop holds 2 or 3 leaves and 100 leaves are strung on each pole. The poles are arranged regularly on scaffolding provided in the barns. They are arranged in tiers one over another and a big barn holds 1,500 poles. Stringing the leaves and arranging the poles in barns are done during the day and the work is completed by the evening. The furnace is started the next morning and hot air is passed through the flues, keeping the ventilators closed. The temperature inside is about 85° F. at the commencement. It is raised to 100° F. in 30 hours gradually, when the leaves change colour and turn yellow. The temperature is then raised further, at 3° to 5° F. per hour and held at 120° F. for about 24 to 30 hours. The yellow colour is fixed in the leaf during this stage. The leaves are next dried by raising the temperature to 130° F. The ventilators are

opened partially at the commencement and fully later. If the ventilators are not opened suitably, the moisture escaping from the leaves is redeposited on their surface and causes sponginess. The drying of the leaf web takes about 48 hours. The leaf stalks and the mid ribs are still somewhat moist and require to be dried by raising the temperature further. The temperature is raised gradually and maintained at 145° F., for about 8 hours and later raised and maintained at 165° F., till the stalks get dried. The schedule of curing operations followed at Guntur is as follows:

Stage No.	Temperature in degrees Fahrenheit	Period in hours	Remarks
1.	88 — 89	30	Yellowing stage. The ventilators are
	89 — 95	6	kept closed.
	95 — 100	4	
2.	100 — 120	30	Fixing the colour. Raise the temperature to 120° F., at 2° per hour. Ventilators are opened partially in the beginning and fully later.
3.	125	4	Leaf drying stage.
	130	6	
	135	8	
	140	8	or until leaf is dry.
4.	140 — 145	6	Stalk drying stage. Close ventilators, raise temperature at 2° per hour. The temperature is maintained finally at
	165		165° F., till the stalks are dry.

The dried leaves are cooled in rooms during the night and formed into heaps next morning. There is a slight fermentation in the heap and the leaves become pliable and mellow in course of time. The heaps are opened out

and the leaves are re-bulked once in a way. They are graded finally after curing according to colour, leaf size, freedom from blemishes etc., and packed for export.

2. *Rack curing*. 'Virginia' tobacco leaves are also strung and cured on racks at Guntur, without using barns. The rack cured produce is not so uniform or of such high quality as the barn cured produce. The mature leaves are stripped from the plants and strung evenly on a 3-ply jute twine to a length of 7½ feet and the twine is kept stretched by fixing the two ends to a thin bamboo pole, 9 feet long, called 'tier poles'. These poles are arranged close to one another on racks erected in sheds. Direct sunlight is avoided, but there is free aeration, and the temperature and aeration are not under control. The leaves kept on the racks turn yellow in about a day. The tier poles are then shifted to racks, built in the open and exposed to sunlight directly. The yellow colour, produced on the leaves while in the shed, is fixed now, in about 2 days. The racks are covered with mats during the night, to prevent dew settling on the leaves. The mat cover is removed during the day. The leaves and the mid ribs get dry in about a fortnight. If rains are received during this period, the leaves do not get cured properly and are spoilt. But rains are not had at Guntur, during this period.

The leaf strings are then detached from the tier poles, and the dry stringed leaves are kept heaped in rooms. The heaps are opened out and re-built once in 2 days for about a month and once a week during the next 2 months. The maximum colour and aroma are produced during this period of curing. The object of opening and rebuilding the heaps is to aerate the material and

prevent over-heating, and spoilage. After the leaves are cured thoroughly, they are removed from the strings, graded according to colour, size, and other qualities and packed in bales of 200 lb. each.

The cigar tobacco also is cured on racks, but rather differently. An yellow colour is desired in cigarette leaf and a dark colour in the cigar leaf. The cigar tobacco is grown in rich soils with heavy manuring. The plants are topped and only a few leaves are allowed to develop on the plants. Therefore, the leaves are rather thick and the nicotine content is high. The plants are cut when the leaves are mature, with red and yellow spots developed on the surface. They are left in the field exposed to the sun for a day. They lose a little moisture and are not then so brittle as when freshly harvested. They are then strung close to one another with 5-ply jute twine and 450 leaves are strung in a length of 7½ feet. These are tied to racks kept in the open field, rather close to one another, when the leaves get dried slowly. The drying takes about 40 days. The leaf strings are then removed from the racks and formed into heaps in shade. The heaps are opened out and rebuilt once in 10 to 14 days. After some time, when the heaps are being re-made, a liquid made with 3 lb. of jaggery, 4 ounces of myrobalan powder and 4 gallons of water, is sprayed as each layer is laid. Four gallons of the liquid are required for about 5,000 lb. of leaves. The addition of jaggery solution speeds up the fermentation in the heaps, which have to be shifted more frequently then till fermentation ceases. The tobacco develops a dark colour and strong flavour during fermentation. The leaves are then detached from the strings, the mid ribs are removed and the stripped leaves

are sorted into filler, binder and wrapper, and packed separately into bales.

The curing of the cigar tobacco is done differently in Tamil Nad. The tobacco plants are cut in the evening, after the leaves develop brown patches, and are left in the field. The plants wilt a little during the night. They are gathered into small heaps of 25 to 30 each, in the morning. The heaps are sometimes covered with straw. The plants are spread out every evening and gathered into small heaps in the mornings. The plants are collected finally after about 35 days, when the leaf webs are dry and tied to horizontal poles with coir twine. In the case of quid tobacco, the fresh plants are tied to the poles straightaway. These are kept on racks in open verandahs. The plants are examined every day and the position of the individual plants are changed inside out, to facilitate uniform drying. The webs get dry in about 40 days. The mid ribs get dry in another 30 days. The plants are then removed both in cigar and quid tobacco and heaped, with the butt ends outside. The heaps are 5 feet across and 5 feet high. They are covered with gunny sacking and weighed with stones at the top. They are opened out and rebuilt on alternate days to start with, when fermentation is vigorous and the material gets heated up considerably. If the heaps are not shifted frequently, there is considerable rise of temperature and the leaves get spoilt. The shifting of the heaps is less frequent later, when the fermentation slows down. When the temperature in the heap does not rise, the fermentation ceases. The leaves turn brown and develop the characteristic aroma and flavour during the period of fermentation. The leaves are then stripped from the plants and made into small bundles which can be held in

the hand. These are called 'hands'. If the proper flavour is not developed and the original green raw odour persists, a small quantity of jaggery solution is sprinkled over the leaf bundles at the time of forming the heap. This promotes further fermentation and the required flavour is developed in course of time. After curing, the 'hands' are untied, the leaves are graded according to size and colour, and made into neatly shaped 'hands' and packed for the market.

3. *Pit curing.* This method is sometimes adopted for curing quid tobacco in Coimbatore district. The tobacco plants are cut a little earlier than for curing on racks. They are wilted for a day or two in the field and packed in earthen pits, lined with *ragi* straw. The pit is opened after 12 to 15 days and the plants are dried on racks for a time. The plants are then split into two longitudinal halves, strung with coir twine on to racks and dried in shade or in the open. After 3 or 4 days, the plants are heaped and the curing is done in the same way as in the case of rack cured cigar tobacco, but without the addition of jaggery solution. The resultant product is dark in colour and rather strong. It is in demand in certain markets, particularly in the Gudiatham market.

Seed production. A few plants are left in the field without topping, for the production of seed in the case of cigar and quid tobacco. The seed heads are cut, when the seed pods are dry. The seeds obtained from a few heads are sufficient for meeting the requirements of individual farmers.

In cigarette type tobacco, topping is not done and all plants produce seed and 200 to 300 lb. of seed are

produced from an acre. These seeds are not, however, required for sowing, as the farmers purchase their requirements of seedlings at the time of transplantation The 'Virginia' tobacco seed contains 35 to 37 per cent of oil. The oil dries a little slower than linseed oil and is semi-drying in nature. It can be clarified and used for mixing with paints and enamels. It is edible, and can also be used for making soaps. The tobacco seed cake contains 30 to 35 per cent of protein, 15 to 16 per cent of ether extractives and about 27 per cent of carbohydrates. It compares favourably with gingelly oil cake and can be used safely as a concentrated feed for milch cows, buffaloes and bullocks.

Yield. The yield of cured tobacco leaves per acre is in general of the following order in South India:

Cigarette tobacco – 500 to 750 lb.
Cigar tobacco – 1,000 to 1,500 lb., and
Quid tobacco – 2,000 to 2,500 lb.

XIII. 2. Arecanut (*Areca catechu* Linn.)

Vernacular names: Tamil - pakku; Malayalam - pakku; Telugu - vakka; Kannada - adike; Hindi - supari.

Importance. Arecanut is used widely in India and is offered to guests and visitors on ceremonial, festive and religious occasions, along with betel leaves. It is chewed with betel leaves and it is considered to be of some assistance in promoting digestion. It is an astringent and anthelmintic. It is a recognised vermicide in veterinary practice. The inflorescence has a fragrant odour and it is worn over the hair by women in South Kanara and Mysore. The husk of the nuts can be used for manufacturing low grade paper.

Distribution. Arecanut is a crop of the humid tropics and it requires a heavy and well distributed rainfall of at least 80 inches annually or alternatively assured irrigation all round the year. Thus, it is cultivated only in countries where such conditions prevail. It is chiefly grown in Ceylon, Straits settlements, Malaya, East Indies, India etc. Its cultivation in the Indian Union is confined to the West Coast districts from Bombay to Trivandrum, Bengal and Assam, which are regions of heavy rainfall, ranging from 80 to 200 inches a year. It is also grown in inland areas, which receive about 30 inches of rainfall, as at Mettupalayam, which have adequate irrigation facilities. India produced from an estimated area of 259,670 acres 82,377 tons of arecanut during 1945—'46. She has to import annually about 40,000 tons of arecanuts to meet her requirements. The estimated extent of areca cultivation and production of arecanuts in India during 1945—'46 are given below:

Name of State	Extent in acres	Production of arecanut in tons
1. Madras—		
a. Malabar 85,000 acres		
b. South Kanara 19,000 ,,		
c. Other places 3,500 ,,	107,500	28,190
2. Bombay	19,400	12,300
3. West Bengal	5,870	1,831
4. Assam	25,000	9,587
5. Mysore	37,100	10,180
6. Coorg	800	439
7. Travancore-Cochin	64,000	19,850
Total India	2,59,670	82,377

Source: Kunhikannan Nambiar K., *Survey of Arecanut crop in the Indian Union.*, 1949.

Adaptation. Arecanut is cultivated on a variety of soils, like the laterite soils along the West Coast, the red loamy soils of Mettupalayam, the alluvia of Bengal and Assam and the loams in Orissa. Lands with adequate drainage facilities are chosen and this is a pre-requisite for areca cultivation, combined with heavy rainfall or copious irrigation. It cannot stand drought.

The areca palm does not tolerate extremes of temperature and does not thrive in very hot or cold climates. An equable temperature of 70° to 80° F. appears to be most favourable for arecanut. Where it is hot, it is grown under the shade of jack, mango and coconut trees. Areca palms are planted close to one another for providing shade and a cool atmosphere. The young seedlings are planted with bananas with the same object. At the same time, the crop does not stand too much of cold. The nuts do not harden and develop properly, when the altitude is over 3,000 feet above sea level.

Habit. The areca palm is a delicate and graceful tree with a thin slender stem, surmounted by a spreading crown carrying 8 to 10 leaves. It may live for 60 to 80 years, but may not bear economically beyond 40 years. The inflorescence is a spathe springing from the axles of leaves, with a number of subsidiary branches. The flowers are borne on these branches, the male flowers towards the tip and the female flowers near the base. The female flowers open and become receptive after the male flowers in the inflorescence open and shed their pollen. Fertilisation is, therefore, usually by pollen from other trees. The nuts take 8 to 9 months for development from the time of fertilisation. The immature nuts are soft and contain tannin in considerable quantities. The tannin content gets reduced as the nuts ripen.

Varieties. There are no distinct varieties in India. The fruits are green in colour and change to yellowish orange or scarlet, as they mature. There are also varieties in Mysore which have yellow coloured tender fruits. The size and shape of the nuts are variable and the various markets have their special preference. The nuts are oblong in shape and big sized in South Kanara and parts of North Malabar, medium sized in South Malabar, Travancore-Cochin and 'Maidan' area in Mysore and very small at Mettupalayam. They are small and almost spherical in parts of North Malabar and 'Malnad' in Mysore.

Planting. The fruit, or the nut as it is commonly called, has a thick fibrous husk enclosing a single seed. These nuts are planted in the gardens directly sometimes, but more commonly seedlings are raised in nurseries and planted when they are 1 to 4 years old. Trees which have thick crowns, a large number of leaves and heavy bearing capacity should preferably be selected as parent trees. The middle bunches on the trees are harvested for seed after one or two fruits ripen and drop down. The ripe bunches are cut and lowered to the ground with ropes. The nuts are dried in shade for about a week, or directly in the sun for about 2 days, before they are sown. The nuts harvested from January to April are used for sowing along the West Coast.

The seed nuts are taken from young trees in Travancore and from old trees alone in Malabar and it cannot be said which is definitely better. It appears probable from what is known of other palms that seed nuts may be gathered from adult trees, which are 25 to 35 years old and neither too young nor too old.

Nursery. A well drained site in the areca garden is selected and prepared by digging it thoroughly. No manuring is done. The nuts are planted at distances of 6 to 9 inches from one another, with the tip of the seed slightly exposed and irrigated regularly. They germinate in 45 to 60 days. The seedlings are lifted when they are 9 months old and transplanted in a second nursery 1½ feet apart. They are transplanted in their permanent site after 1 to 2 years.

Transplantation. Bananas are first established in the garden intended for arecanut, for providing shade for the young areca seedlings. The spacing given between areca seedlings is very variable, ranging from 6 ft. x 6 ft. to even 12 ft. x 8 ft., with about 1,200 to 360 plants per acre. There is no definite information as to which spacing is the most advantageous. It can, however, be said that many areca gardens are overcrowded and that 500 to 600 seedlings may safely be planted in an acre, without erring on the side of under or over spacing.

Pits 1½ ft. square are dug to a depth of 2 to 3 feet and filled with weathered soil and cattle manure. The seedlings are planted near the surface at a depth of 9 inches, where the water table is high and the surface layers of soil are likely to remain damp and moist for a large part of the year. They are planted at a depth of 2 to 3 feet from the surface, where the water table and the sub soil water are low down.

Intercultivation. This varies in the different tracts. In Mysore, South Kanara and parts of Malabar, the areca gardens are regularly weeded and hoed twice a year. Successful farmers consider that intercultivation increases the productivity of the gardens by 10 to 20 per cent. On the other hand, intercultivation is seldom done in

Travancore, West Bengal and parts of Malabar, where popular opinion holds that intercultivation severs the surface roots and affects the bearing of the areca trees. These are conflicting views, which cannot be reconciled without conducting proper trials. There is no doubt that gardens have to be cleared of heavy weed growths, for the maintenance of the condition of the garden and the trees. There is also the need for taking precautions against the erosion of the surface soil by heavy rains. Suitable embankments, ridges and drainage channels for the disposal of surplus rains are necessary. A thick leaf mulch including rough twigs is provided once in 3 years in the heavy rainfall 'Malnad' regions of Mysore. The big twigs do not decompose and prevent the surface soil from being eroded by the heavy rains and the overflowing water. In the Mettupalayam region, where the rainfall is as low as 30 inches annually, drainage is not a problem and on the other hand, arrangements have to be made for adequate irrigation and the retention of moisture in the soil at a safe level.

Manuring. Manurial practices vary widely. Manuring arecanuts is in vogue in Mysore, North Kanara, South Kanara and South Malabar. It prevails to a small extent at Coimbatore, but not at other places. The manure applied consists of variable quantities of cattle manure and green leaf. Certain manurial trials conducted at the Marthur farm in Mysore indicate that arecanuts can benefit by annual applications of 10 cart-loads of cattle manure and 5 cart-loads of green leaf per acre and supplemented advantageously with concentrated fertilizers made up of 80 lb. of ammonium sulphate, 200 lb. of groundnut cake, 200 lb. of concentrated superphosphate and 300 lb. of potassium sulphate per acre, once in 3

years. In heavy rainfall regions subject to leaching, regular protective green manuring is necessary.

Irrigation. Arecanuts are grown largely in regions of heavy and well distributed rainfall, which do not require any supplementary irrigation. In regions of low and unevenly distributed rainfall, irrigation is necessary. It is provided at Ponnani, Cochin, South Kanara and Mysore, only during the summer months. Irrigations are given in the other months also at Coimbatore, when necessary. Lift irrigation is provided at Ponnani from November to May, once in 2 or 3 days. This increases the cost of cultivation. Irrigation is given once a fortnight in the 'Malnad' of Mysore, from tanks at the head of the gardens.

Under-planting. Once an arecanut garden is started, it continues to be perpetually so thereafter; it is under-planted with areca seedlings at periodic intervals and trees in several stages can be seen in almost all gardens. In Mysore, under-planting is done, when the trees first planted begin to bear and later when the second plantings commence bearing. Thus, in a garden about 20 years old, there will be one batch of trees 20 years old, another 10 years old and a third one just planted, giving a total of 1,200 trees per acre, even when 400 seedlings are planted originally. In Kasargode, under-planting is done only when the trees are over 30 years old. Otherwise, it leads to overcrowding and considerable competition between the trees in bearing and those in the growing stage. This must ultimately tell on the vigour of the trees and their production.

Inter-cropping. This is an universal practice in all areca areas. Coconuts, mango, jack, banana, betel vines

and cardamoms are some of the common crops grown along with arecanuts. These provide shade and keep the gardens cool. In parts of North Kanara, excellent betel vines are grown with arecanuts. The gardens are manured heavily and attended to properly and large profits are obtained both from the betels and the arecas.

Harvest. The harvest of arecanuts is spread over a period of about 5 months in the year and the commencement of the harvest varies from place to place, depending upon the seasonal conditions and the stage of maturity at which the nuts are harvested. Regions which harvest tender nuts start earlier and those which harvest fully ripe nuts start much later in the year. The number of harvests in a year is normally 3, with an interval of 40 to 50 days, between the successive harvests, though in certain cases there may be an additional harvest. Tender immature nuts are harvested and cured in South Malabar, Coimbatore and 'Maidan' area of Mysore, with the harvest commencing in June-July. Harvest commences in October in the Mysore 'Malnad' area. Ripe nuts alone are harvested in South Kanara and North Malabar and the harvest commences in November.

The areca palms are close to one another and the climber gets up a tree for harvesting nuts, and moves from tree to tree, without getting down for hours at a stretch. When a slight swing is given to the tree on which he is, it sways to and fro. When it approaches a neighbouring tree, he gets hold of the latter and releases the hold on the first tree and hoists himself safely on the second tree. It requires considerable experience and a certain dexterity. The climber can cut the bunches of nuts from adjacent trees also with a bill hook attached to a long pole, but the bunches drop down and the nuts get

scattered over the garden and require to be picked later. In many regions, the cut bunches are lowered to the ground with long ropes secured to the tree by the climber. In certain cases, the bunches are dropped down by him and received on a piece of hessian held by another man on the ground.

Mature nuts have a bright yellow colour, tinged orange or light red. The stage of harvest of green immature nuts is judged by husking a few nuts and pressing with the finger nails. If the finger nails get into the nut with some resistance, it is right for harvest. If they get into the nuts rather easily, the nuts are immature and if they do not get in at all, the nuts are over-mature.

Yield. There are 800 bearing trees per acre and 3 bunches containing 450 nuts on each tree on the average at Mettupalayam and the yield is about 360,000 green nuts, or 100 bags annually. Tender nuts alone are harvested there for being cured. An average yield is about 800 lb. of cured nuts per acre. The estimated average acre yield of nuts is 625 lb. in Malabar, 500 lb. in the 'Maidan' area of Mysore and 800 lb. in the 'Malnad' area of Mysore. In South Kanara, the average yield of ripe nuts is 1,600 lb. per acre, with heavy yields going up to 3,300 lb.

A number of types of arecanuts are produced for catering to the requirements of the different markets. In the West Coast regions and Assam, fully ripe moist nuts are used for chewing. In the off season, the nuts are kept moist by steeping them in water or by keeping them in underground pits and used for chewing. In Tamil Nad and Andhra Desa, tender nuts which have been boiled and cured in various ways are used. Under each of these types, there are many grades and varieties.

Processing tender nuts. Tender raw arecanuts contain considerable tannin, which can be injurious. The tannin content falls down when the nuts mature and also when they are boiled. Tender nuts are husked, sliced in different ways and boiled with water for about 2 hours. The cooked nuts are removed and the residual liquid is concentrated to a thick fluid. This is mixed with cooked nuts, which are then spread out for drying. The concentrated fluid gives a colour and a gloss to the cured nuts. Dyes are also sometimes used for the purpose. Condiments like *omum* (*Carum copticum* C. B. Clarke.) are added to special varieties of nut.

There are nuts in different stages of maturity even on the same bunch and the cured nuts are not uniform in quality. The green nuts are sorted and those of the same stage of maturity are cured together, when large quantities are handled, for securing uniformity in the quality of the product. The cured nuts are valued for their colour, appearance, and stage of maturity. Tender glossy nuts are prized the most.

Tender immature nuts, which are cut across into 2 pieces and cured without colouring, go by the name of 'kalli pakku'. Nuts, which are slightly more mature, are cut longitudinally into 3 or 4 pieces before curing. These are coloured with the extract of the boiling liquid and are glossy in different degrees and go by the name of 'vettu pakku'. When the nuts are cut into thin disks, cured and coloured, the product goes by the name of 'churul pakku' or 'lavanga churul'. Dried ripe nuts, without any curing, are called 'kottai pakku'. Green moist nuts go by the name of 'pachai pakku'. Ripe nuts kept moist by steeping in water are called 'neer pakku'.

CHAPTER XIV

GREEN MANURE CROPS

Green manuring and green leaf manuring. Growing a crop *in situ* and incorporating it with the soil is called 'green manuring'. When green leafy material is collected from other places and used instead, it is known as 'green leaf manuring'. Leguminous crops alone are used for green manuring ordinarily, as they fix atmospheric nitrogen and leave it in the soil, besides adding organic matter to it. It is an agricultural practice which is beneficial in the following ways :

1. Leguminous green manure crops fix atmospheric nitrogen, which is a distinct addition to the land. The cost of growing them is negligible and the land is supplied with nitrogen at a small cost. Application of other manures or fertilizers is more costly.

2. When a green manure crop is ploughed in, it decomposes easily, without leaving much of residue in the soil. The amount of humus added to the stock already present in the soil is negligible. Green manure differs from cattle manure in this respect. The latter adds considerable humus to the soil, while green manure adds but little. If, however, the green manure crop is allowed to mature and is ploughed in, it decomposes slowly and some humus is added to the soil. But the nitrogen in the green manure will be locked up in the humus and will not be available fully to the next crop.

3. The green manure added to the soil promotes the activity of soil micro-organisms, carbon dioxide is

liberated, the chemical reactions in the soil are speeded up and more plant food is made available. Organic acids produced during the decomposition of green manure help to release phosphates and make them available for the use of the next crop.

4. The green manure also improves the structure of the soil. This is in proportion to the humus added to the soil by it. Humus acts as a binding material in light soils and increases their water holding capacity. It promotes also the formation of crumbs in heavy soils, which leads to an improvement in their absorptive capacity and percolation.

5. The green manure crop withdraws plant nutrients from the lower layers of soil and concentrates them on the surface when ploughed in and this assists the succeeding crop.

6. The tracks left behind in clayey soils by the decay of the deep roots of green manure plants may not be completely obliterated and this may assist drainage.

Subsidiary objects of green manuring. Green manure crops are raised primarily with the object of supplying nitrogen to the soil cheaply and adding to the stock of humus in the soil to the extent possible. They are also grown with certain other objects, namely to serve as catch crops, shade crops, cover crops, or forage crops.

1. Catch crops. These are intersown a little before harvest or a little after, in the standing crop, in temperate countries, with the object of utilising the nitrates formed during the off season, which may otherwise be lost by leaching. The nitrates are used by the catch crop and are not allowed to go to waste. The catch crop is

ploughed in as green manure or grazed off. Utilising the nitrates formed is the primary object and green manuring is only incidental. Conditions for taking such catch crops for utilising nitrates do not exist in South India. The low level of moisture in the soil during the off season does not favour the activity of the nitrifying organisms and there is not any large production of nitrates. Nor do the conditions favour the leaching of the nitrates that may be formed.

Green manures are sown sometimes amidst the standing rice crop in clayey soils just before harvest, with the object of utilising the moisture in the soil, instead of allowing it to be wasted by evaporation. The crop thus sown is also a catch crop.

2. *Shade crops.* Green manure crops can be sown in young orchards with the object of providing shade and preventing the surface soil from getting heated up in summer. Otherwise, the tender roots of the young fruit plants are affected adversely by the high temperature of the soil.

3. *Cover crops.* Green manure crops are grown sometimes with the object of clothing the soil surface with a vegetative cover, particularly in hill slopes during rainy weather to prevent the erosion of the soil by running water. This can also be done with the object of preventing wind erosion. The crop chosen should be capable of covering the surface during the rainy or windy season, as the case may be, and it may be ploughed in as green manure, later.

4. *Forage crops.* Green manure crops may also be sown with the object of taking a few cuttings of green fodder for cattle, in the early stages. Early growths of

pillipesara (*Phaseolus trilobus* Ait.), sown in the standing rice crop, are used for feeding cattle and the crop is ploughed in as green manure, finally.

Green manuring possibilities

1. *Dry lands.* The rainfall in South India is of a monsoon type. There is a definite rainy season, when crops are grown under rainfed conditions. The rainfall is limited and taking a green manure catch crop is not feasible, ordinarily. It will utilise the stock of moisture in the lower layers of the soil and its decomposition later will make further demands on the soil moisture and the succeeding crop will suffer consequently. Green manuring dry lands is not practicable, except in the West Coast and the Nilgiris, where rainfall is abundant.

2. *Garden lands.* Green manuring garden lands is not practised, though it can be done in between two main crops, under certain conditions.

(a) The green manure crop should be capable of being fitted into the existing rotation and system of cultivation. It should be capable of making good growth within a limited period, so that it does not interfere with the cultivation of the other crops in the rotation. The usual two year rotation of Coimbatore includes 3 crops. Sorghum is raised during summer from March to June, followed by Cambodia cotton from September to the following April and *ragi* from May to September. The land is fallow from September to next March, when sorghum comes in again. Sunhemp can be sown towards the end of September, allowed to grow with the north-east monsoon rains and ploughed in by the middle of December. This will not

interfere with the existing system of rotation and cropping.

(b) The green manure should be capable of producing abundant green matter, free of thick woody growths, which render their incorporation and decomposition in the soil difficult.

(c) The green manure crop should be a leguminous one, so that a good quantity of atmospheric nitrogen can be fixed.

(d) The green manure crop should be capable of being raised at little cost. If it is grown during rainy seasons, the cost of cultivation is limited to the cost of preparing the land and the seed. Irrigation will be necessary in other seasons and it will increase the cost of cultivation.

3. *Wet lands*. Green manuring is particularly suitable for wet lands. It is being practised to some extent by farmers in South India. Green manure crops are grown during the off season and there are great possibilities of developing green manuring practice extensively. The application of green leaf collected from various shrubs and trees growing in *porombokes*, roadsides, tank bunds and forests is a traditional agricultural practice in rice culture under swamp conditions. Green manuring is an extension of the practice of green leaf manuring.

In wet land areas, where irrigation facilities are limited to a short period, only one crop of rice is raised and the land lies fallow thereafter for 7 to 8 months in the year. Suitable green manure crops can be raised during the fallow period in single crop wet lands which receive some rains during summer.

Where irrigation systems supply water over a longer period, 2 crops of rice are raised in the year, with a short interval between the first and second crops, when the land is prepared for the latter and cannot be used for raising green manure crops. The second crop comes to harvest sometime in February-March and the land is fallow for 3 to 4 months afterwards. Green manure crops can be raised during the period, in regions where there are some summer rains. In certain regions, the land is prepared by dry-ploughing and rice is sown with the seasonal rains in June. The lands are flooded later, after receipt of water in the irrigation system. Since these are dry-ploughed during the fallow period, green manure crops cannot obviously be raised in such areas.

Sowing green manure crops. This is done in various ways. The seeds are broadcasted over the standing rice crop, 3 to 5 days prior to the harvest of rice, when water stands in the field, or when the surface has sufficient moisture for germinating the seeds strewn on the surface. The germinating seedlings are not much affected at the time of the harvest of the rice. The green manure crops establish properly and make some growth with the moisture available in the soil. Rains received during the summer months, if any, benefit them. Suitable long duration green manure crops are indigo (*Indigofera tinctoria* Linn.), wild indigo (*Tephrosia purpurea* Pers.) and pillipesara (*Phaselous trilobus* Ait.) for single crop wet lands, and daincha (*Sesbania aculeata* Pers.) and *S. speciosa* Taub. for double crop wet lands. Redgram, cow pea and lablab are also used as green manure crops sometimes.

Summer rains are assured in certain regions, which permit green manure sowings being done 3 to 4 months

FIG. 44. Applying green manure intersown in a banana field.

Courtesy:—Director of Agriculture, Madras.

FIG. 45. Sunhemp being ploughed in as green manure with a disk plough.
—*Courtesy: Director of Agriculture, Madras.*

in advance of the rice season. The lands are dry-ploughed and sown to suitable green manure crops with the summer rains. They come up fairly well with the moisture in the soil. Where, however, there are irrigation facilities, the crops are irrigated 2 or 3 times. They make vigorous growth and produce abundant green matter, which can be used for 4 to 5 times the cropped area.

Fertilizers for green manure crops. The production of green matter in green manures is limited by the plant food elements deficient in the soil. Nitrogen and phosphorus alone are deficient in South Indian soils. Leguminous green manure plants are able to fix atmospheric nitrogen and do not depend upon the nitrogen in the soil. When the soil is rich in nitrogen, leguminous plants do not fix nitrogen so well, as when grown in poor soils,as they tend to take in soil nitrogen in preference to atomspheric nitrogen. The application of phosphatic fertilizers improves the growth of leguminous crops markedly and promotes the fixation of nitrogen by profuse nodulation. The phosphorus in the green manure is in organic combination and becomes available for use by the succeeding crop. The application of phosphates to the green manure is thus useful for the following crop also.

Daincha (*Sesbania aculeata* Pers.) It is a vigorous crop that adapts itself to varying conditions of soil and climate. It comes up well in loamy and clayey soils and is highly resistant to drought as well as stagnation of water. It makes good growth in 3 to 6 months and produces 10,000 to 20,000 lb. of green matter per acre. The seed rate commonly adopted is 20 lb. to an acre, though higher rates of seeding assist in producing plants with thin stems. The stems get woody after about 3 months of growth

and the crop may then be grazed with cattle or topped and the aftermath allowed to shoot through the swath of tops left in the field. The tops can also be composted in small pits in the field itself.

Sesbania speciosa Taub. It resembles daincha in general appearance and performance and is its close relative. The stem is not so woody and hard as that of daincha. The crop is raised by broadcasting seeds at 25 to 30 lb. to an acre. The seed coat has to be slightly abraded by gently pounding with sand to promote full germination. Green matter yield is 25,000 to 30,000 lb.per acre, after 4 to 5 months of growth. Seedlings can also be raised and planted on the edges of rice fields close to the bunds, 3 to 4 feet apart, at the time of planting rice. This does not interfere with the growth of rice and mature *speciosa* pods can be gathered from the fifth month onward, for seed purposes. This will enable each farm to be self-contained with regard to seed requirements and special areas need not be set apart for the purpose. The seedlings can be planted 2 to 3 inches apart similarly during the first crop season and these provide up to 2,000 to 3,000 lb. of green leaf, for being applied to the second crop rice. These practices can be adopted for solving the problem of the supply of seed and of green manure for the second crop rice, which cannot be manured in any other way.

Wild indigo or kolingi (*Tephrosia purpurea* Pers). It is an indigenous green manure crop, which is particularly suitable for sandy soils and single crop lands. It is a very hardy drought resistant plant, which makes slow growth and is on the land for 6 to 8 months. It is not grazed by stock and does not require any protection in the field.

The seeds have a waxy impermeable seed coat, which has to be abraded slightly by pounding with sand, before it is sown. Steeping the seeds in boiling water for 2 to 3 minutes is equally effective in promoting germination. The seed sown in an acre is usually 20 to 25 lb. If *kolingi* is sown continuously for 3 or 4 seasons, the seeds shattered by the crops produce voluntary plants every year and sowings thereafter are not necessary. The seeds remain dormant in the swamp soil during the rice season and when the soil starts drying after the harvest of rice, the *kolingi* seeds in the soil germinate and the crop is in the field, till the land is next prepared for rice. The yield of green matter is 8,000 to 10,000 lb. to an acre.

Indigo or *avuri* (*Indigofera tinctoria* Linn.) It is a long duration crop, which resembles wild indigo, but has a more leafy habit. It comes up well in clayey soils, particularly when one or two irrigations are given. The seeds are sown at 20 lb. to an acre and the yield of green matter is 8,000 to 10,000 lb. to an acre.

Pillipesara (*Phaseolus trilobus* Ait.) It is a herbacious vinous plant, which comes up well in moist clayey soils. It is intersown in the standing rice crop, 3 to 5 days before the harvest of rice in coastal Circars. The growth of the crop is rather slow in the beginning and vigorous later, when it covers the ground completely. It is grazed with cattle or cut once or twice and allowed to grow uninterruptedly for about 6 weeks before receipt of water in irrigation channels. When pods are borne heavily, they are gathered when dry and the crop is ploughed in as green manure. The usual seed rate is 10 to 15 lb. to an acre. The green matter yield ranges from 8 to 10 thousand pounds per acre. The seeds are sometimes used as a pulse, as a substitute for greengram.

Sunhemp (*Crotolaria juncea* Linn.) It is a vigorous growing green manure crop, which can be ploughed in in about 7 weeks. It comes up well in loamy soils, particularly under irrigation. The usual seed rate is 25 to 35 lb. to an acre and the green matter yield is 15,000 to 25,000 lb. per acre. The crop is at times subject to considerable damage by leaf eating caterpillars and flea beetles.

Green leaf manuring. This consists of the application to land of green leaf, gathered from shrubs and trees growing in waste lands and forests, or brought from other fields. The common shrubs growing on waste lands are *Cassia auriculata* Linn., *Dodonia viscosa* and *Calotropis gigantea* (Willd) R.Br. Green leaf manures have the same effect as green manures on land and the crops following.

The practice of growing *pungam* (*Pongamia glabra* Vent.) in waste lands, specifically for providing green leaves for manuring rice fields, prevails in Mysore State. Lands, which cannot be cultivated economically alone, are planted to *pungam*. *Pungam* is a leguminous tree, which comes up well and provides heavy loppings year after year.

Leguminous trees like *pungum* and *Cassia siamea* Lam. can be planted in waste lands, for the production of green leaves for manurial purposes. Tree crops do not require any attention after they get established and start growing vigorously. Suitable species of trees provide some fuel, light timber and leaves for fodder during periods of scarcity of fodder and straw.

Gliricidia maculata H. B. K. Syn: *G. sepium* (Jacq.) Stend. It is a shrubby type of plant, which comes up well in moist situations as by the side of water courses

and tank bunds. Under favourable conditions of soil and climate, it takes a tree habit and grows to 25 to 30 feet. It is interplanted in tea and coffee plantations for providing shade. It can be grown in waste lands, farm road sides, field bunds etc. In wet lands, it can be planted on big field bunds. It provides loppings twice or thrice a year, amounting in all to 25 to 40 lb. per shrub, after 2 years of growth. When it is lopped regularly, its growth is restricted to 7 to 9 feet and it is without any appreciable root or shade effect on rice crops. Gliricidia can be propagated by planting stem cuttings and seedlings raised in nurseries. Cuttings do not establish so readily as seedlings.

The composition of the common green manures and green leaf manures has been furnished at the end of Chapter II.

CHAPTER XV

PASTURES AND FORAGE CROPS

XV. 1. Pastures

Pastures. Pastures are grass lands. where the grasses growing are grazed with animals. In pasturing with animals, there is no expenditure connected with the raising of fodder crops, their harvesting, and distribution, as in stall feeding. The cost of production of livestock and of dairy produce is therefore kept down and minimised. The maintenance of pastures in other countries, particularly in North America and Australia, is facilitated (1) by land being available extensively for being set apart for the purpose, over and above what is required for arable farming and (2) by conditions of scarcity and costliness of labour required for farm work. Any system that saves labour is welcomed in those countries. North America is estimated to have over 25 per cent of the arable area under pastures and forage crops like lucerne, berseem, shaftol, maize, sorghum, cabbage, turnip, beet root etc. In addition, 90 per cent of corn and oats, 50 per cent of barley, 25 per cent of wheat and rye, all the sorghum and a small percentage of most other crops are estimated to be utilised as stock feed. Of the 33 million acres of cultivable land in the United Kingdom, 20 million acres were under grass and forage crops in 1939, prior to the second world war. In India, on the other hand, 5 million acres representing 1·9 per cent of the total cultivated area of 266 million acres

alone are under forage crops. It is so, because the land available here is limited in relation to the human population and it is required in full for the production of food grains and commercial crops. Crops which provide food for both human beings and livestock are preferred to forage crops, which provide food for livestock alone. Labour is also not scarce as in other countries. The conditions obtaining in India cannot therefore permit land being set apart specifically for pasture and forage crops, except to a limited extent, under certain special cases. A shift to large scale livestock farming cannot take place.

Natural pastures. Grasses and other herbage growing on waste lands afford some facilities for grazing. In addition, arable land of the marginal type is set apart permanently for grazing in other countries. These are natural pastures, where herbage gets established spontaneously without any sowing and provides excellent grazing under proper management. These are permanently under grass. Some of the pastures are closed to grazing and are mowed for hay, after the herbage makes full growth. These are called 'meadows'. The herbage that springs up after the main harvest of the season is called 'aftermath', which is grazed with animals.

Artificial pastures. The inclusion of grasses as one of the rotation crops is a common feature of livestock farming in other countries. The grasses are kept on the land for varying periods of 3 to 10 years and the land is ploughed up later and brought under other crops. The grasses are established by sowing seeds as in other crops. The grass lands, called 'temporary patures' or 'leys', are artificial pastures.

Land is prepared for grasses as for other crops, manured with dung and sown to a mixture of grasses. The term 'grasses' used with reference to grass lands includes all plants sown mixed for the production of herbage. It includes gramineous plants, or the true grasses and also leguminous plants. The seed mixture consists usually of a number of types of grasses and legumes. Thus, one mixture used in America contains alsike clover 2 lb,, white clover 1 lb., alfalfa 5 lb., trefoil 1 lb., orchard grass 4 lb., meadow grass 3 lb., tall oat grass 4 lb., timothy 2 lb., and meadow fox tail 2 lb., making up 24 lb. of seed in all, for seeding over an acre. This mixture contains a number of legumes and grasses. Mixed herbage gives greater yields than single species of either grasses or legumes. The various components in mixtures have different feeding habits and they utilise the fertility of the land more evenly. The inclusion of legumes is advantageous in many ways. The leguminous plants fix atmospheric nitrogen. They are rich in protein, and raise the protein content of the mixed herbage and make it richer. They also enrich the soil. The grasses that are associated with legumes consequently make better growth than when grown alone.

Improved grass strains. The leafy portions of grasses are richer in protein and minerals than the stems, which are fibrous and coarse. Some plants have more leaf and less stem and furnish better feed than others. Such plants are isolated and improved strains of grasses with good leafy habits, that is, those with a greater proportion of leaf than unselected material, are evolved in research centres and distributed to farmers for general cultivation.

Manuring pastures. Pasture grasses need manuring like other crops. Cattle manure is applied to grass lands

at 5 to 10 tons to an acre about once in 3 years and covered by working spike tooth harrows. Intensive fertilization is advocated with a view to improve both the quality and quantity of the herbage produced. Where leguminous plants are not abundantly growing, ammonium sulphate is applied at 1 to 2 cwts. an acre yearly and superphosphate at 4 cwts. once in 3 years. The application of nitrogen improves the yield and the protein content of the herbage. The phosphates are of assistance in establishing and promoting the growth of legumes in the pastures. Potassic manure is applied to light soils at 1 to 2 cwts. an acre in alternate years. Lime is applied to deficient soils at 1½ to 2 tons an acre initially and followed up with annual applications of 5 to 6 cwts.

Cultivation. Regular and systematic cultivation maintains the condition of the herbage. After the growths are grazed down, pastures are worked with spike tooth harrows for spreading the dung voided by animals, as grasses in the dunged spots are apt to make rank growth and these spots are avoided by animals later. In certain cases, termites start breeding under the dung and termite mounds may be formed, as at Hosur in Salem district, unless the dung voided is spread out. When pasture areas are not grazed closely by animals, they are mowed for promoting flush of tender grass, for weakening weed growths and for preventing the formation of seeds. Re-seeding is done when pastures get thinned out and show bare patches here and there.

Rotational grazing. Pastures are divided into blocks, which are grazed one after another in regular rotation. The extent of land available for grazing is thereby limited to the animals and they graze the herbage completely,

without leaving behind coarse growths. After a block is grazed thoroughly, animals are not let into it. The herbage plants make uninterrupted growth, build up their body and are not weakened as in areas grazed continuously without any kind of restraint. The block is opened for grazing again, only after the other blocks are grazed out in their turn, in a regular order, or rotation. Rotational pastures are grazed uniformly and are in a cleaner and better condition than those grazed continuously without a break. Rotational grazing helps to increase the total production of grass, the consequent carrying capacity of the pastures and the total grazing period.

Features of pasture management. Young grass is leafy, with a higher ratio of leaf to stem than mature grass. The leaf often contains 2 to 3 times as much protein as the stem. As the grass makes growth, there is a decrease of protein content and digestibility of the various nutrients, and an increase of fibre content and of the total starch equivalent. Since protein is the most valuable and the costliest of the nutrients, it is advantageous to graze the pastures when the herbage is young. If grass cut after maturity is compared with that cut periodically for obtaining young leafy growths up to the time of taking the mature growth, it is seen that the total protein obtained, the percentage of protein and the digestibility of all the nutrients are greater in the periodical cuts, though the total dry matter and the starch equivalent obtained are less.

Keeping the land for a time temporarily under grass confers certain advantages. The organic matter content of the soil increases, as also the nitrogen content. This

is mainly because the organic matter added to the soil by the dead and decaying roots is not oxidised rapidly as in ploughed land, which is freely aerated by cultivation. The grass roots help to improve the structure and make the soil more granular, in a way which is not quite clear. The capacity of the soil for retaining moisture is improved and the erosion of the soil is reduced. Thus, the inclusion of grasses in the rotation materially assists in the maintenance of the fertility of the soil.

Pastures in South India. Pastures in South India are limited to hill slopes, waste lands, and channel and tank bunds, which provide some light grazing. Small areas have been set apart near villages, to serve as common grazing grounds. They are overstocked and the animals do not allow grass to make its appearance. Regular pastures are maintained only in Guntur, Nellore and Coimbatore districts by some big farmers. In Nellore, upland areas are set apart for use as pastures, where natural grasses get established spontaneously. Cattle are sent here from wet land regions during the rice cultivation season. In Guntur, lands adjoining channel and river courses are left uncultivated and allowed to develop grass spontaneously. *Chengalli gaddi* (*Iseilema laxum* Hack.), a hardy, vigorous and nutritious grass gets established freely. These are the only permanent natural pastures here.

Artificial pastures. Big breeders in the Kangayam tract in Coimbatore district maintain temporary pastures regularly, on which they bring up their Kangayam herds of cattle. Arable land is divided into blocks of 30 to 50 acres each and these are planted all round with *mullu kiluvai* (*Commiphora berryi* Engl.) stumps during the

rainy season, which get established and form a thick impenetrable hedge. Live fencing dry land is a special feature of this tract, not seen elsewhere in South India. Wells are often provided in these paddocks, with one side sloping for animals to get down for drinking water. Grass is one of the crops in the regular rotation. The land is ploughed 2 or 3 times and sorghum is sown in July-August with the commencement of the south-west monsoon rains and covered by working ploughs. *Kolakattai* grass (*Cenchrus ciliaris* Linn.) seeds are broadcasted over it at 25 lb. per acre, when some rain is expected. The grass seeds do not germinate when covered by ploughing and are consequently left exposed. Light harrows can, however, be worked or babul branches dragged over the land across the furrows for levelling the land and covering the seeds slightly, which does not interfere with their germination.

The young grass gets established during the course of the year. Sorghum is harvested in December-January and the young grass starts growing with the summer rains and it is allowed to be grazed by young stock with the commencement of the south-west monsoon. A good sward is formed by the time the north-east monsoon closes in December, when adult cattle are let in for grazing. The land is under grass for 4 or 5 years and is ploughed and sown to other crops later.

Sorghum, sown with the grass, is called the 'nurse' crop. Rye, oats, barley and wheat are sown as nurse crops in other countries, and grazed off. The advantages associated with nurse crops are that (1) two crops are raised together and no expenditure is involved in raising the grass, (2) the land gives a return when the grass is

establishing and building up the plant body, and getting fit for being grazed, and (3) the weeds that spring up are kept in check by the more vigorous nurse crop. Raising nurse crops has certain disabilities also. Grass has to be sown thick to secure a fair stand, in competition with the nurse crop, and the competition is severe in years of deficient rainfall, when the grass tends to die out in numbers. The grass sown with the nurse crop does not make vigorous growth initially, as when sown pure. But the advantages out-weigh the disadvantages and raising nurse crops with grass is an accepted practice associated with ley-farming.

Pasture grasses of South India. A number of grasses comes up in waste lands and cultivated fields, but a few of them alone are widely distributed and provide some grazing in South India. They are considered below:

1. **Hariali** or **dhub** grass (*Cynodon dactylon* -Pers.) is found growing all over South India. It is a cosmopolitan grass, which comes up well under varied conditions, in waste lands, field bunds and even in cultivated fields. It has a deep, spreading root system with thick underground stolons, which make its eradication in cultivated fields difficult. It prefers heavy clayey soils, though it comes up fairly well in light soils and even in alkaline soils. It is very nutritious and young grass contains 20 per cent of protein on a dry basis.

2. **Ginger grass** (*Panicum repens* Linn.) is confined to wet land bunds and moist situations. It has thick underground rhizomes, which resemble ginger. It has a robust growth habit and provides good grazing. It has a matted root system, which binds the wet land bunds.

3. **Kolakattai** grass (*Cenchrus ciliaris* Linn.) comes up well in light red gravelly soils. It is distributed all over Coimbatore district, a low rainfall region, but where the rains are distributed over the several seasons of the year. It flushes after even light rains and serves as a stand-by for the Kangayam cattle bred here. It is a very nutritious grass, particularly in the young stages, when the protein content is about 16 per cent on a dry basis. It gives up to 15,000 lb. of green grass per acre under rain fed conditions.

4. **Chengalli gaddi** (*Iseilema laxum* Hack.) is a vigorous grass of the Ongole tract, which comes up well in heavy black soils, which are rich in lime. This is considered to be responsible for the big bony build of the Ongole breed of cattle raised in this region. It gives 3 cuttings in a year and yields up to 10,000 lb. of green grass per acre.

5. **Spear grass** (*Heteropogon contortus* Beauv.) comes up fairly well in light, red gravelly soils, as at Hosur in Salem disirict. The seeds are awned and bristly and injure the mouth of cattle feeding on mature grass. The awns are removed by working combing machines in advance of mowers, when the grass is cut for hay. It has a poor feeding value, having only about 6 per cent of protein on a dry basis.

6. Leguminous herbage plants, particularly the clovers, get established along with true grasses in temperate countries and enrich the herbage in protein. Attempts at acclimatising them in South India have not been successful. A few legumes like *Rhynchosia minima* D. C., *Indigofera ennaephylla* Jacq., *Alysicarpus rugosns* D. C. and *A. longifolius* W & A. come up as stray plants

in waste lands along with grasses during the rainy months in South India and die out later. They do not provide much feed to the grazing stock and may be said to be without much effect on the quantity or quality of the herbage.

XV. - 2 Forage crops

Forage crops. Pastures and natural grass growths provide a very limited grazing only for cattle here. Cattle live mainly on cereal crop refuse or straw. Forage crops are cultivated in limited areas only. Sorghum is cultivated in the black soil regions of Tirunelveli, Madurai, Ramanathapuram, Guntur and Krishna districts and used mainly as dry fodder. It is grown in small areas in garden lands in the Central districts, for providing green fodder to mhote bullocks during the summer months. Mhote work is a heavy strain on the animals and they require some green feed for maintaining their condition. It indicates that the farmers know the value of green feeds, but do not have sufficient surplus land for being set apart for forage crops. Sunhemp is intersown amidst the standing rice crop, a week prior to harvest, in the month of March, in Krishna and Guntur districts. It comes up well with the moisture in the soil. It is cut at the time of flowering, dried and stacked with rice straw in alternate layers and the feeding value of the straw is thus improved. Cattle are allowed to graze daincha sown for green manure in Madurai district, so that they may build up condition and get fit for the strenuous work connected with the preparation of the land for rice in wet lands. *Pillipesara* grown for green manure in Godavari and Krishna is grazed with cattle and the crop is allowed to make

uninterrupted growth for about 6 weeks, before taking up the preparation of the land for the next rice crop.

A few perennial fodder crops have been introduced and tried in agricultural stations in South India. Among them, Guinea grass, Napier grass, water grass or buffalo grass and lucerne have done uniformly well, under irrigated conditions. A number of cuttings is taken each year and the crops are kept on the land for 6 to 8 years. These crops are not cultivated outside the agricultural stations, excepting by a few farmers in small areas.

1. **Guinea grass** (*Panicum maximum* Jacq.). It comes up very well in rich loamy soils which have adequate irrigation and drainage facilities. The land is prepared by ploughing 3 to 4 times, manured with cattle manure at 10 to 20 cart-loads to an acre and laid into ridges and furrows, 3 feet apart. The individual tillers, which spring up from the base of the Guinea grass stumps, are separated and used as planting material. They are called 'slips'. They are planted 2 to 3 feet apart on one side of the ridges and 5,000 to 7,000 slips are planted in an acre. The crop is irrigated once a week for about 2 months and once a fortnight later. It makes vigorous growth and the first cutting can be taken in about 75 days and the subsequent ones at intervals of 1 to 1½ months, depending upon the rate of growth. The crop is intercultivated 4 to 6 times a year and manured with cattle manure annually at 10 cart-loads to an acre. The individual plants spread out and form big stools in about 2 years and they are then split into 4 quarters and 3 of them are dug and removed. The 'quartering' of the stools may have to be done once a year subsequently.

The annual yield of green Guinea grass is 40,000 to 75,000 lb. per acre. Young and tender growths are nutritious and cuttings have preferably to be taken before flowering. They are consumed by cattle readily. Mature growths are coarse and the harder stems are rejected by stock and there may then be some wastage.

Guinea grass makes very vigorous growth under sewage irrigation. A crop, planted in about 80 acres at the Municipal sewage farm, Madurai in 1922, has been standing as a perennial crop for over 33 years now, and giving about 100 tons of green fodder annually from each acre of land. The soil, being of an open gravelly type, has not developed sewage sickness, and it has facilities for adequate drainage and aeration.

Rotational harvest. Perennial forage crops are harvested in small quantities each day and a daily supply of green fodder is maintained regularly. If a crop gives 10 cuttings a year, the interval between successive cuttings is 36 days, roughly. The total fodder area can then be divided into 36 plots and one plot harvested each day in a regular sequence. Thus, if there are 144 rows of fodder, 4 rows are cut daily, commencing from one end of the field and finishing with the last 4 rows on the 36th day. The 4 rows cut on the first day have had 36 days of growth by now and the next round can be commenced with them. This system of harvest gives an interval of 36 days, between the successive cuttings in any part of the field.

2. Napier grass (*Pennisetum purpureum* Schum.). This is a hardy perennial grass introduced from South Africa, where it grows to a height of 10 to 12 feet. Elephants roaming inside Napier grass forests are masked by the

grass, which has therefore been given the synonymous name of 'Elephant grass'. Napier grass is cultivated like Guinea grass and the annual yield is 60,000 to 90,000 lb. to an acre. It provides a coarse fodder, with thick woody stems which are rejected by stock, except when they are cut in the young stages. There is apt to be considerable wastage when the fodder is cut later.

3. **Water grass** (*Brachiaria mutica* Stapf.). This is also cultivated similarly, but the ridges for planting the grass are made closer, 2 feet apart. The thin straggling shoots of the grass are used as the planting material. Fairly mature shoots of the grass, about 18 inches in length, are pressed into the soil, leaving the 2 ends sticking out. They are planted close to one another along the sides of ridges. The crop gives 60,000 to 70,000 lb. of green grass per acre annually, in 8 to 10 cuttings. Animals do not consume the grass readily till they get accustomed to it. Mature stems are rejected by stock, and there is no wastage when tender grass is provided. Grass cut in the morning with the dew on is apt to be rejected by stock. Water grass is suitable for wet land conditions, which are not suitable for the other perennnial fodder grasses.

4. **Kolakattai grass** (*Cenchrus ciliaris* Linn.). This is an indigenous pasture grass which comes up well in light red soils. It can be cultivated as an irrigated perennial fodder grass in light soils, in the same way as Guinea grass, except in the following respects. Seedlings are raised in nurseries like *ragi* seedlings, with a seed rate of 1½ lb. per cent of nursery. Seedlings raised in 3 cents are required for planting an acre. They are 9 inches high in about 25 days, when they are pulled out and transplanted with a spacing of 1 foot between plants

on one side of the ridges. The ridges can be 1½ to 2 feet apart. The grass tillers profusely and builds up a good tussocky sward in 6 months. It is very nutritious and the stems are thin and succulent. Cattle consume it with relish and do not reject any part of the grass. It grows to a height of about 2 feet and is not showy in the field like the other perennial fodder grasses, but yields up to 120,000 lb. of green grass per acre annually. It is superior to others from the point of yield, palatability to stock, fine quality of the stem and nutritive value. The grass does not come up in clayey soils.

5. Lucerne (*Medicago sativa* Linn.). Lucerne is a leguminous forage crop, which has an unrivalled popularity all over the world. It is a perennial which can be kept on the land for 6 to 8 years, for providing repeated cuttings like the perennial grasses. If all the leaf shoots are cut, leaving bare stumps only, lucerne tends to die out early. A few young shoots have to be left on the plants at the time of taking the cuttings. Lucerne fodder has about 20 per cent of protein on a dry basis and is a protein rich fodder. It is also rich in calcium and phosphorus, in common with other legumes and is a valuable feed for stock. Green lucerne is apt to set up bloat in cattle, when supplied in large quantities and green lucerne can be given in the beginning at 5 to 7 lb. a day and raised to 20 lb. gradually, as the animals get accustomed to it. Some animals are susceptible to bloat more than others and feeding lucerne has to be regulated by the peculiarities of individual animals. The bloat can be avoided by feeding cattle with straw and filling their stomach partially, before feeding lucerne. Lucerne can can be dried and made into hay and used for feeding milch cattle and it does not set up bloat like green

lucerne. It can successfully replace protein rich concentrated feeds for medium grade cows.

Lucerne comes up well as an irrigated crop in South India, in clayey soils and clay loams, which have facilities for adequate drainage, though it is cultivated more commonly as a rain fed crop in temperate countries. The land is prepared thoroughly by ploughing, manured with cattle manure at 20 cart-loads and superphosphate at 1½ cwts. to an acre and thrown into ridges and furrows 2 feet apart. Lucerne seeds are dibbled in threes and fours on the sides of ridges, 6 inches apart. Four to five pounds of seeds are required for planting an acre. When the crop is raised in a new locality, it may not thrive for want of the specific legume bacilli in the soil, which have to be then introduced. The crop is weeded and irrigated when necessary like the fodder grasses. It comes up well and the first cutting can be taken in about 90 days after planting and the subsequent ones at intervals of 30 to 45 days. Eight to 12 cuttings can be taken in a year depending upon the fertility of the soil and the manure and irrigation provided. Vigorous growth is maintained from the second year, only when manured each year with 10 cart-loads of cattle manure and 1½ cwts. of superphosphate per acre. The use of superphosphate is not common in India, though leguminous crops require phosphatic manuring and respond to it very well.

The yield of green lucerne fodder ranges from 40,000 to 70,000 lb. per acre annually in South India.

XV. 3 - Conservation of fodder

The growth of grass is limited to the rainy seasons in India, when cattle and other livestock get some natural

grazing. Even during these periods, there is not any large surplus grass which can be conserved and kept over for being used at the other parts of the year, except in certain isolated areas. At other places, crop refuse of various kinds are dried, kept in stack and used as feed for stock. They represent material left behind after the separation of grains and are of poor quality and low nutritive value, as nutrients are translocated from the various plant tissues to the grains at the time of their development and maturity. Cereal crop refuse, made up of the stem and leaves, is the chief fodder for cattle. It is called 'straw'. Leguminous crop residue, called '*bhusa*' and empty ear heads of cereals also serve as feed to a small extent.

Livestock have natural grazing for a large part of the year in temperate countries, as in Europe. Surplus grass is made into hay, dried grass or silage. These supplement the natural grazing, which may be negligible in winter.

Hay. When grass is cut, dried in the sun and converted into a dry feed for stock, it is called 'hay'. Fodder crops can also be made into hay in a similar way. The entire crop is cut before maturity and dried in both cases, and it is, therefore, more nutritious than straw, which is crop refuse only. When hay is made properly, it has a light green tinge and a pleasant characteristic aroma. It is also pliable. It has a fairly high nutritive value, when it is made with mixed herbage containing legumes. The stage at which herbage is cut has a large influence on the quality of the hay. Tender grass has a high protein content and is more digestible than mature grass, and the earlier the grass is cut, the better is the quality of the resulting hay.

The herbage in meadows and pastures reserved for hay are allowed to make uninterrupted growth till flowering, without allowing stock to graze them. This is much later than the grazing stage. It is then cut with mowers worked with horses and tractors in clear bright weather, so that the mowed grass can be dried quickly. The mower has a cutter bar with a number of triangular knives fixed to it. The cutter bar slides to and fro inside slotted projecting steel fingers. The herbage is held between the knife blades and the steel fingers, and sheared. The action resembles that of hair clippers, in a general way. The mowed herbage is laid in rows, called 'windrows', on one side of the mower. The windrows are periodically shaken and re-formed with hand rakes, or with machines called 'tedders', to facilitate uniform drying. Otherwise, the grasses on the surface get bleached, their leaves get too dry and tend to get detached during handling and those inside continue to remain green and moist. Rains, received at the time of making hay, are detrimental. The windrows have then to be turned oftener to promote drying and to reduce damage. After the leaves of the herbage get dry and before the stems are completely dry, the partially dried material is made into small heaps called 'cocks' and left in the pastures. The cocks are not disturbed till the leaves absorb moisture from the stems and get pliable. If the material is kept in the cocks longer, the leaves get dry again and are shattered during handling. Since the leaf is the most valuable part of the hay, all operations connected with the making of hay has to aim at the avoidance of loss of leaves, as far as possible. The hay is then moved to its permanent site, stacked, and covered with straw or coarse grass.

If there is too much moisture in the hay at the time of stacking, there is considerable fermentation in the stack, leading to a rise of temperature and loss of carbohydrates. When the rise of temperature is very much, the hay is charred in pockets here and there. Spontaneous combustion of the stack takes place rarely, when the hay is stacked with considerable moisture.

The following losses take place at the time of making hay, even when it is made under the best of conditions.

(1) The cells in the fresh grass live and continue to respire till they are killed by loss of moisture. The carbohydrates in the grass are then oxidised and converted to carbon dioxide. When the grass is dried quickly under favourable conditions, there is the least loss of carbohydrates.

(2) When the herbage is being dried by exposing it to sun, there is loss of carotene along with green colouring matter in the leaves. Carotene is the precursor of vitamin A, and the loss of carotene leads to loss of vitamin A potency. The loss of carotene is proportional to the exposure of the material to sun light. The herbage should not, therefore, be exposed to sun light any longer than necessary for drying. Variable quantities of vitamins B and C are also lost during drying, but these are not of much consequence when the hay is intended for feeding ruminants, which synthesise vitamins B and C in their rumen. Hay gets irradiated by exposure to the sun and gets enriched in vitamin D.

(3) The leaves of herbage plants are thin and get dried earlier, before the thicker stems lose their moisture. Bits of dry leaves get broken and get detached during

handling. The loss of leaves by shattering is greater with legumes than with grasses. Keeping down the loss of leaves to the minimum at the time of making hay assumes importance, as the leaves are rich in protein and minerals.

(4) The hay is subject to bacterial fermentation, which leads to loss of carbohydrates. The fermentation is facilitated by the residual moisture in the hay and the areation inside the stack. It is responsible at the same time, for the development of the characteristic sweet aroma and pliability associated with hay, which are valued by farmers. A certain amount of fermentation is necessary and desirable, but too much of it can lead to considerable loss. This can be avoided by controlling the moisture in the hay before stacking.

(5) When there are rains at the time of making hay, there is considerable leaching of the nutrients and fall in the quality of the hay. Further, wet weather leads to delay in drying and consequently to increased respiration and fermentation. When the weather is wet at the time of making hay, loss of quality of the hay may be considerable, which has given rise to the common saying 'make hay, when the sun shines'.

The following percentage composition of some samples of hay gives an idea of the variability in the nutritive value that can be expected in hay of different types :

The composition of hay is subject to wide variation and it is influenced by the type of herbage used and the conditions under which it is made. The Bellary hay has a very low protein content of 2·44 per cent, while at the

Name of hay	Crude protein	Crude fibre	Carbo-hydrates
Lancashire hay [2]	12·90	31·13	45·07
Shropshire ,, [2]	9·17	32·03	48·67
,, ,, [2]	4·81	34·61	53·87
Hariali ,, (Bangalore) [1]	11·06	25·86	46·19
Kolakattai ,, (young) [1]	16·89	28·49	40·78
,, ,, (prime) [1]	10·01	35·33	42·60
,, ,, (ripe) [1]	6·38	33·30	49·71
Bellary ,, [1]	2·44	36·90	45·36
Berseem ,, [1]	14·70	30·56	40·99
Cow pea ,, [1]	15·31	34·84	35.44
Lucerne ,, [1]	21·26	29·41	35·18

Source: 1. Sen K. C., *The nutritive values of Indian cattle foods and the feeding of animals.*, Bulletin No. 25., Manager of Publications, New Delhi, 1952.

2. Watson S. J. *Science and practice of conservation: Grass and forage crops.*, 1939.

other end the *kolakattai* hay has 16·83 per cent and compares favourably with legume hays, and it is nearly as rich in protein as cotton seed. When hay is made properly with suitable herbage, it is of good quality and can then replace concentrated feeds to a large extent.

There is no surplus grass in South India to be made into hay in a large way. The livestock research station at Hosur in Salem district is making hay regularly. The grass in the hills of the Bellary district is made into hay and kept stacked at Dornakal, for use as famine reserve fodder in the Ceded Districts. Hay is made nowhere else in South India.

Dried grass. Drying grass artificially in a large scale and using dried grass as stock feed is a recent

development of the second world war period. This was developed in England. She was importing large quantities of grains and oil seed cake before the war, for feeding stock. The imports were cut off during the war and she had to fall on her own resources. The number of stock maintained was reduced considerably and attempts were made in various ways to produce stock feeds. The use of dried grass is one such attempt. Large quantities of heat are required for the purpose and the bulky nature of the grass offered many difficulties initially. Suitable drying equipment was, however, evolved during the period and some driers are in use today. Fresh grass is chopped into small bits, the stems are crushed between rollers and these are dried in hot chambers at 400° to 600° F. The moisture in the grass is removed rapidly without appreciable loss of nutrients and dry matter, and almost all the goodness of green grass is retained in the dried grass. The cost of drying grass is still high. Young grass of good quality alone is, therefore, dried artificially, and dried grass with a protein content of 9 to 16 per cent is produced, which can replace concentrated feeds successfully. Drying grass artificially avoids the several losses, which occur when it is dried in the sun and made into hay. Hay is a poor feed when compared to dried grass.

Silage. Green fodders can be conserved and retained in a succulent state by keeping them packed in suitable containers, excluding air as far as possible. The green material ferments to a certain extent during the first 2 or 3 months of storage and remains practically unchanged thereafter, up to a year or more. The conserved succulent material is called 'silage'. The process of making silage is called 'ensilage' and the pit or tower, where the green

material is kept packed, is called the 'silo'. Cement tower silos, 10 to 15 feet in diameter and 30 feet or more in height, are in common use in countries like America, Australia and Europe. Side doors are provided on the towers at different heights, for the removal of silage in stages without inconvenience. Green fodder is chaffed and blown into silos with suitable machinery and elevator chutes. They are compacted properly at the time of filling, by trampling. Long unchaffed fodder can also be used, but it does not get packed so well as chaffed fodder, and air is not excluded properly. The weight of the silage ranges from 30 lb. per cubic foot in the upper layers to 50 lb. at the bottom.

Ensilage has been tried in India, chiefly in earthen pits. Pits 8 to 10 feet deep, 6 to 8 feet wide and of variable length are dug in high level areas, where the water-table is 12 feet or more from the surface. The size of the pit is dependent on the quantity of fodder available, and one cubic foot of space is required for every 25 lb. of fodder, or about 90 cubic feet per ton of fodder. Fodder does not pack so well in shallow pits as in tower silos and more space has, therefore, to be provided. Coarse straw is used for lining the bottom, the sides and also for the top over the green material. The fodder is spread out uniformly and trampled well, as each layer is laid. Filling is continued 3 to 4 feet above ground level, the top is given a dome shape to enable rain water being shed easily, covered with a layer of straw and sealed with a thick layer of soil finally. The pit is banked all round with earth, to prevent rain water getting in. The material sinks after a time and cracks developing on the earthen cover are sealed with wet mud, for excluding air.

Changes in silage. The cells in the green fodder put into silos are alive and continue to respire and use up the carbohydrates in the tissues, till they die out. As a result, there is evolution of carbon dioxide and rise of temperature, particularly pronounced in the early stages when there is some oxygen. As the temperature rises, the environment becomes favourable for the activity of bacteria, which are present on the surface of the fodder. They use up the carbohydrates and produce carbon dioxide, organic acids, mainly lactic, acetic and butyric acids, and small quantities of alcohol. The products of decomposition are variable depending upon the carbohydrates available and the aeration in the pit. Two main types of fermentation, namely butyric and lactic fermentation, take place in the silo.

The butyric fermentation is of an anaerobic type, which takes place when air is thoroughly excluded from the silo. Anaerobic organisms of the *Clostridium* group then become active and butyric acid is one of the main products of decomposition. Butyric acid gives a pungent odour to the silage, which is consequently not relished by stock. The anaerobic organisms also favour the activity of certain enzymes, which bring about the degradation of proteins and the production of some putrefactive compounds. These changes are not desired in silage.

When there is some aeration in the silo and a sufficient quantity of sugars in the green material, lactic acid bacteria take the field and bring about lactic fermentation, with lactic acid as one of the chief products formed. When the consequent acidity of the material rises rapidly to 1 per cent at the start itself, the silage that results is of good quality. The production of lactic acid

keeps in check the undesirable organisms. When the acidity reaches 2 per cent, there is cessation of fermentation and the silage keeps in the same state for long periods. While limited aeration induces lactic fermentation, excessive aeration promotes the activity of moulds, which spoil the silage and make it unacceptable to stock.

Fairly mature grasses and cereal fodders are rich in carbohydrates, stiff stemmed and do not get packed tightly. They do not consequently exclude air completely from the silo and favour the activity of lactic organisms. Maize and sorghum in the dough stage have a high carbohydrate content and are ideal for ensiling. They are fibrous and fairly stiff at this stage of maturity and do not get packed tightly in the silo. There is consequently a rapid rise of acidity and good quality silage is produced. Leguminous fodders are, on the other hand, poor in carbohydrates and do not lend themselves for being made into quality silage. They can, however, be mixed with cereal fodders and ensiled. The resulting silage is of good quality and it is fairly rich in protein.

Silage types. Though silage is extremely variable in quality, it can be classified into 5 main types, namely (1) sweet dark brown silage, (2) acid light brown silage, (3) green fruity silage, (4) sour silage and (5) musty silage, depending upon the characteristics of the final product.

1. Sweet dark brown silage. This is dark brown in colour and the depth of colour is an indication of the temperature to which it was subject at the time of active fermentation. This type is produced when the fodder crop (or grass) is mature and has more than 30 per cent of

dry matter at the time of harvest, or when it is fairly mature and is dried for a day before ensiling. The fodder is stiff and does not get packed tightly in the silo, there is free aeration and the temperature is raised initially to 115° to 130° F. Further, the silo is filled intermittently with an interval of a day between successive layers of 3 to 4 feet. The temperature is enabled to rise, before the next layer is laid. When a layer is laid in the silo, aeration is reduced in the layer below, which does not further rise in temperature beyond 1° to 2° F. When such a silo is opened, the top foot layer is mouldy on account of excessive aeration and dryness, and the bottom portion is sour with traces of butyric acid and slightly putrid sometimes. The silage is of fair quality and it has a pleasant smell like over-heated hay. It is dry to the feel and is relished by cattle. Fair quantities of digestible nutrients are lost by fermentation and the silage is not, therefore, the best type.

2. *Acid light brown silage.* This is made from fairly mature crops, or those which have been wilted to a dry matter content of 25 to 30 per cent. The temperature of the fermenting mass does not rise above 114° F. and it may be as low as 85° F., as the aeration in the silo is limited. The silage is yellowish brown to brown in colour and has a pleasant acid smell, due to the presence of small quantities of acetic acid. It is palatable and readily eaten by cattle, but it is apt to loosen and decay the teeth of stock, when it is fed continuously for a long time.

3. *Green fruity silage.* This is the most nutritious and palatable type which can be produced under careful management only. Crops, which are medium ripe with a

dry matter content of 20 to 25 per cent are suitable. Succulent sorghum and maize crops can be cut at the milk stage and ensiled the same day. They pack properly and the temperature does not rise above 86° F. Since the fodder is succulent, large quantities of plant sap are expelled from the lower layers by the weight of those laid above. The sap contains some digestible protein and sugars, and can be collected from tower silos and used for feeding stock. In spite of this loss, the final product is the most nutritious and palatable among the several types. It has an olive green colour and an inviting smell, neither sour, nor sweet, but fresh and fruity.

4. *Sour silage.* This is made from tender fodder, which has less than 20 per cent of dry matter and which gets packed tightly in silos and excludes air effectively. The ensiled material is subject to anaerobic fermentation and the temperature does not rise above 85° F. The silage has an acid smell and a pungent odour caused by the presence of butyric acid. It is consumed by cattle, but not with relish.

5. *Musty silage.* This is produced when ripe crops are ensiled, particularly when they are wilted. The porous nature of the chaffed fodder and the aeration in the silo facilitate considerable rise of temperature and the incursion of moulds. The silage is musty and is rejected by stock. Ripe materials should preferably be ensiled on the same day of harvest and moistened with water at the time of filling the silo. Tender succulent material can be used for the top layers to keep out air to the greatest extent possible.

Losses in ensilage. The following losses take place when silage is being made.

1. There is exudation of plant sap from the lower layers in silos, which are pressed by the weight of the layers laid above. This is referred to as drainage loss and may be considerable in tower silos, which are 30 feet and more in height. The loss of dry matter by the exudation of plant sap may be 3 to 10 per cent, depending upon the succulence and the tenderness of the ensiled material and the pressure exerted by the top layers.

2. There is loss of carbohydrates as a result of respiration in the green material when the constituent cells are alive, and of fermentation after the cells die out. A third of the carbohydrates present in the original material may be lost as a result. The end products of respiration and fermentation are carbon dioxide and organic acids chiefly.

3. There is a certain extent of rotting and spoilage of the silage at the top, however carefully the silo may be sealed. The spoilt material acts as a seal and protects the layers below from aeration and incursion of moulds. Spoilage occurs on the sides also in earthen silo pits and the total loss may amount to 25 to 35 per cent, depending on the size of the pit. The loss is great with small pits. Where the silos are lined properly with cement or other non-absorbent materials, the loss may be limited to 5 to 10 per cent.

4. True protein is broken down and amino acids and simpler nitrogen compounds are formed. Carotene is destroyed to an extent, when the temperature of the silage rises during fermentation. Vitamin C may be destroyed up to 50 per cent and more.

5. A certain loss of dry matter up to 5 per cent occurs even when silage is made under ideal conditions,

The loss is great in silage made in earthen pits, amounting to 50 per cent in small pits, 30 to 35 per cent due to spoilage and 15 to 20 per cent due to respiration and fermentation.

Improvements in ensiling. It has been indicated that when fresh fodder is pitted, it is subject to fermentation, till the acidity rises to 2 per cent and that it remains unchanged thereafter. In the A.I.V. process developed in Finland, dilute hydrochloric and sulphuric acids are sprayed on the chaffed fodder at the time of filling the silo and the acidity of the material is raised and the original pH of the material is brought down from 6—6·25 to 3—4. This suppresses bacterial activity and fermentation effectively, and the material is conserved in the silo, without much change.

In another method, dilute molasses are sprayed instead, at the level of 1 to 2 per cent of the chaffed material. This speeds up fermentation and the loss of carbohydrates in the fodder is minimised. This is particularly helpful in conserving leguminous fodders, which are low in carbohydrate content and which tend to putrefy without such assistance.

Ensilage in India. Silage making has been tried in various places in India and quality silage has been produced. But, it is not likely that it will ever become a feature of farming here, because of certain basic limitations. The farming units are small in general and it may not be possible to set apart areas for the production of green fodder, for the purpose of ensiling. Cement silos of the tower type are efficient, but they are rather costly and beyond the means of most farmers. Further, a tower silo 10 feet in diameter and 30 feet high takes in

35 to 45 tons of green fodder. Such large quantities are not available in individual farms. Nextly, about a 2-inch layer of silage has to be used every day, to prevent the silage from getting spoilt, when once the silo is opened. A 2-inch layer of silage would weigh about 500 lb. and 10 animals would be required for consuming it, in a day. Most farming units maintain less than 4 to 6 animals only. Tower silos are not, therefore, suitable for ordinary forming units, prevalent in India. Silage is also wet and carrying it for feeding animals is inconvenient. The spoilage in silage produced in small earthen pits is too great. All these make silage unsuitable for the ordinary farmers in India.

Silage making may be the only available method of conserving fodder under certain special conditions; ensiling will then be advantageous. *Ragi* is grown extensively in Coimbatore, from July to October-November. It comes to harvest during the rainy season and the green straw cannot be dried in some years, when there is continuous cloudy and wet weather. It can, however, be made into silage which has an agreeable flavour and which is relished by cattle. This has been tried successfully by some farmers. Even in years. when weather conditions permit *ragi* straw being dried, it may be advantageous to ensile it in preference to drying, as the silage is relished by cattle. while the straw is not so readily accepted.

APPENDICES

APPENDIX I

Certain characteristics of improved strains of the various crops released by the (composite) Madras Agricultural Department, for general cultivation in Madras and Andhra States.

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
				I. RICE		
				1. Aduthurai station		
Adt. 1	Red sirumani	16	175	July to September	Parts of Tanjore and South Arcot	White rice
Adt. 2	White sirumani	10	165	,,	,,	,,
Adt. 3	Kuruvai	Nil	95	June	Tanjore, Tiruchirapalli, Chinglepu t, North Arcot, South Arcot, Nellore, Coimbatore, Madurai & Tirunelvel	Do., earlier than local variety
Adt. 4	,,	12	100	,,	(as for Adt. 3)	White rice
Adt. 5	Nellore samba	25	180	June to September	Tanjore, Tiruchirapalli, Nellore, South Arcot, Coimbatore and Tirunelveli	,,

Adt. 6	Red ottadan	13	220	June	Tanjore and Chingleput	White rice, suitable for *Udu* cultivation only
Adt. 7	White ottadan	13	220	,,	Tanjore	White rice, suitable for *udu* cultivation only
Adt. 8	Molagu samba Sirumani	13	150	June to September	Tanjore, Tiruchirapalli, North Arcot & Palghat	Early white sirumani; white rice
Adt. 9	Poonkar	15	120	June	Tanjore, Chingleput, South Arcot, Tiruchirapalli, and North Arcot	White rice
Adt. 10	Korangu samba	9	165	June to September	Tanjore	White rice, very susceptible to blast
Adt. 11	Nellore samba	6	175	July–August	Tanjore, Tiruchirapalli, Chingleput, Salem, Coimbatore, Madurai and Tirunelveli	White rice
Adt. 12	Chitrakali	9	115	June	Tiruchirapalli, South Arcot, Tanjore, North Arcot, and Chingleput	,,
Adt. 13	Sanna samba	7	160	July to September	Tanjore and Tiruchirapalli	,,
Adt. 14	Vellai kar	9	115	June	Tanjore, Tiruchirapalli, Salem and South Arcot	,,

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
Adt. 15	Senkuruvai	25	110	June	Tanjore, Tiruchirapalli, Chingleput, Salem and South Arcot	White rice
Adt. 16	Konakuruvai	25	115	,,	Tanjore	,,
Adt. 17	Muthu samba	10	165	July–August	South Arcot	,,
Adt. 18	Vellai kuruvai	12	125	June	Tiruchirapalli and Salem	,,
Adt. 19	Sarapalli	19	109	,,	Tiruchirapalli	,,
Adt. 20	Hybrid kuruvai	25	105	,,	Tanjore	,,
Adt. 21	Vadan samba (Tanjore)	16	150	July to September	,,	Red rice
Adt. 22	,, of North Arcot	24	155	July	Semi-dry areas in Chingleput, South Arcot, North Arcot and Nellore	Brownish white rice
Adt. 23	Kullan kar	16	130	February–March	Tanjore and South Arcot	Red rice

Adt. 24	Poon samba	15	150	September–October	Tiruchirapalli, in tank fed areas	White rice
Adt. 25	Adt. 2 x Co. 4	9% over Adt. 2	165	July to September	Tanjore and South Arcot	White rice and resistant to blast
			2. Ambasamudram station			
Asd. 1	Kar samba red	21	115	May–June	Tirunelveli	Red rice
Asd, 2	Kar samba white	10	110	,,	,,	White rice, good for *iddlies*
Asd. 3	Veedhi – vidangan	15	130	,,	,,	Red rice, not lodged by wind
Asd. 4	Kuruva – kalayan	35	135	September	Tank fed areas in Tirunelveli	Semi-dry, drought resistant; red rice
Asd. 5	Karthigai samba	15	150	October	For late planting in November in Tirunelveli, South Arcot and Ramanathapuram	White rice
Asd. 6	Anaikomban	12	170	September	Tirunelveli	,,
Asd. 7	Kar samba red	12	110	June	,,	Red rice
Asd. 8	Thuyamalli	26	86	June and October	Tirunelveli and Ramanathapuram	,,
Asd. 9	Avasara samba	13	90	May–June	Tirunelveli and Ramanathapuram	,,

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
Asd. 10	Kolavalai	11	176	September	Coastal taluks in Tirunelveli district.	Withstands stagnation of water; Dull white rice.
Asd. 11	G. E. B. 24 Kavingan-poothala		150	October-November	Tirunelveli and Ramanathapuram	Fine white rice, in substitution of Asd. 5, with 14% of increased yield
3. Coimbatore station						
Co. 1	Peria kichili		155	July	Coimbatore and Tiruchirapalli	Isolated from G.E.B. 24
Co. 2	Karthigai samba	8	157	October–November	Tirunelveli and Ramanathapuram	Suitable for late planting, white rice
Co. 3	Vellai samba	9	161	July-August	Coimbatore and Malabar	White rice
Co. 4	Gobi Anaikomban	11	192	,,	Coimbatore	Resistant to blast and suitable for popping

Co. 5	Chinna samba	12	164	July	,,	White rice
Co. 6	Sadai samba		176	June–July	,,	,,
Co. 7	Sadai samba		176	June–July	Coimbatore and Tiru-chirapalli	,,
Co. 8	Tirunelveli Anaikomban	17	190	September	Tirunelveli	,,
Co. 9	Tirunelveli kar samba red	14	110	May–June	,,	Red rice
Co. 10	Gobi kar	17	120	April–June and December-February	Coimbatore	White rice
Co. 12	Sendhinayagam	13	190	September	Ambasamudram (Tirunel-veli)	,,
Co. 13	Arupatham kodai	19	110	June and February	Madurai, Coimbatore and Chingleput	,,
Co. 14	Perun thandu vellai samba Co. 3 × a tall Burma variety	10% over Co. 3	179	June–July	Coimbatore and Salem	,,
Co. 15	G.E.B. 24 × Adt. 15	15	190	,,	Nellore, Cuddapah and Krishna	White rice; local name, Jada Mola-kolukulu

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Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
Co. 16	Co. 3 × a tall Burma variety	15	190	June–July	South Tamil Nad	White rice, blast resistant; local name, Bontha Molakolukulu
Co. 17	Chinna vadan samba	25	179	July–August	Chingleput, Nellore, Chittoor, North Arcot and South Arcot	Semi - dry, white rice
Co. 18	Vellai kar	12	125	July and November	Chingleput	White rice
Co. 19	Chingleput sirumani	12	190	June–July	Chingleput and Tanjore	Tasty, white rice
Co. 20	Thella sanna vadlu	9	120 130	January July	Chittoor	White rice
Co. 21	Arupatham samba	16	100	June and January	Salem	Red rice
Co. 22	Manavari	20	115	November	,,	,,

Co. 23	Rangoon samba	14	135 140	January November	Coimbatore	White rice
G.E.B. 24	Konamani of Krishna		149	June–July November	Coimbatore, Tirunelveli	Fine, white rice very popular
Co. 25	Co. 4 × Adt. 10	49% over Adt. 10	195	June to September	The entire Tamil Nad	White rice, blast resisting, called hybrid sirumani
Co. 26	Co. 4 × Adt. 10	40% over Adt. 10	200	,,	,,	White rice, resembling Nellore samba
Co. 27	Pudupati samba	10	160	July–August	Salem	Fine white rice
Co. 28	Bangara theegalu	12	150	,,	Ceded districts	Dull white rice
				4. Mangalore station		
Mgl. 1	Billi kayama	30	127	October	South Kanara	White rice
Mgl. 2	Red kayama	13	127	,,	,,	,,
				5. Palur station		
Plr. 1	Garudan samba		170	August-September	South Arcot	,,
Plr. 2	Chitrakali		105	December January	Chingleput	,,

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
				6. Pattambi station		
Ptb. 1	Aryan	15	150	May	Malabar & South Kanara	Red rice
Ptb. 2	Ponnaryan	15	135	May	,,	,,
Ptb. 3	Eravapandi	8	128	September	Malabar	,,
Ptb. 4	Vellari	22	140	September	Malabar & South Kanara	,,
Ptb. 5	Veluthari kayama	15	145	May	Malabar & South Kanara	,,
Ptb. 6	Athikraya	18	145	September	South Kanara	,,
Ptb. 7	Parambu vattan	13	125	May	Malabar	,,
Ptb. 8	Chuvannari thavalakunnan	17	130	May	Malabar & South Kanara	,,
Ptb. 9	Veluthari thavalakunnan	13	145	May	Malabar & South Kanara	Whits rice

Ptb. 10	Thekkan cheera		100	December	Malabar & South Kanara	Red rice, suitable for I, II and III crop seasons
Ptb. 11	Halliga	9	145	May	South Kanara	White rice
Ptb. 12	Chitteni	13	130	September	Malabar	Red rice
Ptb. 13	Kayama	21	135	May	South Kanara	White rice
Ptb. 14	Mascathi	19	130	May	South Kanara	White rice
Ptb. 15	Kavingan poothala	18	165	August	Malabar, Tanjore and and South Arcot	White rice, suitable for water logged conditions.
Ptb. 16	Kavingan poothala		155	July	Northern Circars	White rice; early
Ptb. 17	Jeddu halliga	23	150	May	South Kanara	White rice
Ptb. 18	Eravapandy	23	130	September	Malabar	Red rice
Ptb. 19	Athikraya	16	145	September	South Kanara	,,
Ptb. 20	Vadakkan	45	120	September	Malabar	,,
Ptb. 21	Thekkan	14	130	September	Malabar	,,
Ptb. 22	Velayutha vattan	44	120	April	Malabar	,,
Ptb. 23	Cheriya aryan		120	April	Malabar	,,
Ptb. 24	Chuvanna vattan		120	April	Malabar	,,

Name of strain 1	Parentage 2	Percentage increased yield of strain over parent 3	Duration of strain in days (Seed to seed) 4	Time of sowing 5	Suitable regions 6	Remarks 7
Ptb. 25	Thonnoran		120	April	Malabar	Red rice
Ptb. 26	Chenkayama	24	120	May	Malabar	,,
Ptb. 27	Kodiyan	40	160	September	Malabar	,,
Ptb. 28	Katta modan		100	May	Malabar	Red (early) rice
Ptb. 29	Karuthan		93	May	Malabar	Red rice
Ptb. 30	Chuvana modan		88	May	Malabar	,,
Ptb. 31	Elappapoo chamban	14	110	July	Malabar	,,
Ptb. 32	Aruvakari	16	130	July	Malabar	,,
			7. Tirurkuppam station			
Tkm. 1	Pisini	20	140	August–September	Chingleput North Arcot and Chittoor	Red rice

Note : Strains Ptb. 1, 2, 5, 7, 8, 9, 11, 13, 14 and 17 are suitable for the first crop season (autumn), 3, 4, 6, 12 15, 16, 18, 19, 20 and 21 are Suitable for the second crop season (winter) and 10 for the '*punja*' or the third crop season (spring).

Tkm. 2	Sembalai	30	140	August–September	Chingleput and South Arcot	White rice, with light yellow tinge
Tkm. 3	Sornavari	15	110	September	Chingleput and South Arcot	White rice
Tkm. 4	Yerra sanna vadlu	40	135	January	Chittoor	Dull white rice
Tkm. 5	Manakkattai	16	135	September and January	Chingleput, North Arcot and Chittoor	Red rice, robust, drought resistant, suitable for all soils & cosmopolitan in habit.
Tkm. 6	Sanna Sornavari Co. 18 × Co. 24		110	,,	,,	Fine, white rice
			8. Wynad station			
Wnd. 1	Pal thondi	38	150-180	October and January	Wynad Hills	Brownish white rice
Wnd. 2	Mara thondi	25	155-200	October	Wynad Hills	Red rice, comes up in all soils
			9. Anakapalli station			
Akp. 1	Bobbiliganthi		137	June–July	Visakhapatnam and Srikakulam	White rice, suitable for high lands, drought-resistant

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
Akp. 2	Sunki sannam		141	August	Visskhapatnam and Srikakulam	Suitable for medium, or high level lands
Akp. 3	Gunupur sannam		147	,,	Visakhapatnam and Srikakulam	Flinty white rice of superior quality
Akp. 4	Mypali		158	,,	Visakhapatnam and Srikakulam	Cosmopolitan in habit and adaptable to varying conditions
Akp. 5	,,		162	,,	Visakhapatnam and Srikakulam	Of a longer duration than Akp. 4
Akp. 6	,,		154	,,	Visakhapatnam and Srikakuam	Flinty white rice
Akp. 7	Bayyahunda		154	,,	North Visakhapatnam	Coarse variety
Akp. 8	Maharaja bhogam		166	,,	Visakhapatnam and Srikakulam	Fine, white rice, suitable for low lying areas

Akp. 9	Bangara theega		168	August	Visakhapatnam, Srikakulam & East Godavari	White rice
Akp. 10	,,		166	,,	Visakhapatnam, Srikakulam & East Godavari	Finer than Akp. 9
Akp. 11	Rama sagaram		166	,,	Visakhapatnam and Srikakulam	White rice, suitable for rich low lying soils
			10. Berhampur station			
Bam. 1	Boroponko		160	June	Ganjam	Light red rice suitable for parboiling
Bam. 2	,,		160	,,	Ganjam	Finer than Bam. 1
Bam. 3	Bayyahunda	19	167	,,	Ganjam	White rice
Bam. 4	,,		167	,,	Ganjam	Finer than Bam. 3
Bam. 5	Ratnachudi	14	174	,,	Srikakulam and Visakhapatnam	White rice
Bam. 6	,,		174	,,	Visakhapatnam and Srikakulam	Grain shorter than Bam. 5
Bam. 7	Navakoti sannam	19	174	May	Visakhapatnam	White rice
Bam. 8	Navakoti sannam	14	174	,,	Visakhapatnam	White rice, suitable for low lying rich areas

Name of strain 1	Parentage 2	Percentage increased yield of strain over parent 3	Duration of strain in days (Seed to seed) 4	Time of sowing 5	Suitable regions 6	Remarks 7
Bam. 9	Mypali	24	174	May–June	Visakhapatnam, Srikakulam and Ganjam	White rice
Bam. 10	,,	17	180	,,	Visakhapatnam, Srikakulam and Ganjam	,,
			11. Buchireddipalem station			
Bcp. 1	Sanna molakolukulu	15	180	June-July	Nellore	White rice, suitable for late planting
Bcp. 2	Potti molakolukulu	12	180	July–August	Nellore	White rice; blast & drought resistant
Bcp. 3	Atragadda	30	208	,,	Upper reaches of Nellore	White rice
Bcp. 4	Pishanam	20	150	September	Nellore	,,
Bcp. 5	Sanna vadlu	16	190	August	Nellore	,,

12. Maruteru station

Mtu. 1	Bontha akkulu	20	194	May–June	East and West Godavari	Cosmopolitan habit suitable for saline soils, submersible soils, etc ; white rice
Mtu. 2	Potti akkulu	16	196	,,	East and West Godavari	White rice, suitable for rich soils
Mtu. 3	Potti basangi	12	150	,,	Godavari delta	White rice, suitable for rich soils and early planting
Mtu. 4	Pedha basangi	9	155	,,	Uplands of Godavari, Krishna and Guntur	White rice, suitable for soils of average fertility
Mtu. 5	Bontha krishnakattukulu	12	200	,,	Godavari deltas	White rice
Mtu. 6	Potti atragadda	16	208	,,	,,	Suitable for low lying areas
Mtu. 7	Gutti	16	220	,,	,,	Non-lodging and non-shedding, suitable for indifferent water supply, white rice
Mtu. 8	Vanki sannam	10	120	January	,,	White rice

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
Mtu. 9	Garikka sannavari	30	120	January	Godavari, Cuddapah and Tiruchirapalli	White rice
Mtu. 10	Sanna krishna-kattukulu		195	May-June	Godavari deltas	White rice, finer than Mtu. 5
Mtu. 11	Konamani	30	209	,,	Krishna and Godavari deltas	White rice, suitable for submersible lands.
Mtu. 12	Pedha atragadda		210	,,	Krishna	White rice
Mtu. 13	Delhi bhogam vanki sannam			,,	Krishna and Godavari deltas	Fine rice, suitable for export
Mtn. 14	Bontha atragadda		200	,,	Godavari deltas	White rice, non-lodging, suitable for ill drained lands
Mtu. 15	Dalwa sannam; Garikka sannavari × Nallarlu		125	January	Godavari, in regions, where there is no dearth of water	White rice, Non-lodging and non-shedding

Mtu. 16	Badava kusumakonamani × a floating Burma rice		200	May-June	Northern Circars	White rice, can stand submersion
Mtu. 17	Kodi budama	14	125	,,	Heavy black soil areas in Godavari, Krishna and Guntur, under rain fed conditions, with 20-30″ of rainfall, during the growing period	Red rice
Mtu. 18	Kodi jilama	9	140		,,	,,
Mtu. 19	Sanna kusuma- a natural cross from G.E.B. 24		200	,,	Krishna and Guntur	White rice, does not lodge even in rich soils. Yields up to 22% over Mtu. 7
Mtu. 20	Punasa basangi		135	,,	Northern Circars	White rice, non-lodging in cyclonic weather in November
Mtu. 21	Prayaga		170	June	Godavari deltas	White rice, for ill-drained areas
Mtu. 22	Pedha kusuma	30	180	May-June	Northern Circars	White rice of good quality

Note: Mtu. Strains 1. 2 3, 4, 5, 6, 11, 14 and 19 are suitable for the main crop of the delatic areas of Godavari; Mtu. 3, 4, 7, 8, 11, 12, 13 and 19 for the main crop of the Krishna delta. They are suitable for those areas alone, where nurseries are sown in May-June and transplanting ,seedlings is done in July. They make poor growth when planted later, as the season of their flowering is fixed; they are season-bound.

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
			13. Samalkota station			
Slo. 1	Punasa konamani		180	June	Godavari and Krishna	White rice
Slo. 2	,,		199	May-June	,,	,,
Slo. 3	Konamani	14	206	,,	East Godavari	,,
Slo. 4	,,	7	206	,,	,,	,,
Slo. 5	Palagummasari		199	,,	,,	White rice, for light soils
Slo. 6	Punasa akkulu		199	,,	,,	White rice, for poor low lying, saline soils
Slo. 7	Bontha basangi		177	,,	,,	White rice, for fertile soils
Slo. 8	Sanna basangi		177	,,	,	Fine white rice

Slo. 9	Gorti rasangi	16	177	May-June	Uplands in East Godavari	Coarse white rice; vigorously growing
Slo. 10	Ratnachudi		208	,,	,,	Veryfine white rice, non - shedding
Slo. 11	Bikkiri sannam		208	,,	Godavari deltas	Suitable for rich soils, where water does not recede at the time of harvest; white rice
Slo. 12	Thella garikka sannavari		100	,,	,,	White rice; can be grown out of season
Slo, 13	Punasa or Gova akkulu	18	206	,,	Northern Circars	White rlce, saline resistant
Slo. 14	Punasa akkulu		206	,,	,,	Fine white rice
Slo. 15	Pedha konamani		213	,,	,,	White rice
Slo. 16	Kasi pichodi		145	May	Gadavari deltas	White rice, finer than G. E. B. 24, can be ratooned
Slo. 17	Gutti kichili		206	May-June	Northern Circars	White rice
Slo. 18	Pedha kichili		213	,,	Tail end of Godavari delta	White rice, suitable for loamy soils

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7

II. SORGHUM

Note: 'R' is rain fed and 'I' is irrigated crop.

1. Coimbatore station

Co. 1	Peria Manjal cholam	R. 12	135	July-August	Coimbatore for grain, and Central and South Tamil Nad for fodder	
Co. 2&3	Talai virichan cholam	R. 12	145	,,	Coimbatore and the Central districts	
Co. 4	Sen cholam	I. 15	90	February-March	Salem and Tiruchirapalli	
Co. 5	Chinna manjal cholam	I. 15	100	February-March	Coimbatore	
Co. 6	Chithra vellai cholam	I. 15	115	February-March	,,	

Co. 7	Kokku vellai cholam	I. 15	110	February-March	Coimbatore, Salem and Tiruchirapalli	
Co. 8	Yennai vellai cholam	I. 15	100	,,	Coimbatore and Tiruchirapalli	
Co. 9	Kesari vellai cholam	I. 15	95	,,	Coimbatore, and Central and South Tamil Nad	A cosmopolitan strain
Co. 10	Pacha jonna (a mutant)	I. 15	145	February-March	Central and South Tamil Nad	For fodder
		R. 12	100	June-August	,,	
Co. 11	,,	I. 15	100	,,	,,	,,
		R. 12	70		,,	
Co. 12	Mottai vellai cholam	I. 15	85 85	January March	Coimbatore and South Tamil Nad	
Co. 13	Yennai vellai cholam	I. 15	105	March	Tiruchirapalli and Coimbatore	
Co. 14	Vellai cholam	I. 15	105	,,	Madurai	
Co. 15	Azhukku vellai cholam	I. 15	105	,,	,,	
Co. 16	Salangai vellai cholam	I. 15	105	,,	,,	
Co. 17	Kattai vellai cholam	I. 15	100	December and March	Madurai, Ramanathapuram and Tirunelveli	

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
Co. 18	Agni kodai x Co. 9	I. 15	95	December and March	Madurai, Ramanathapuram and Tirunelveli	A strain with juicy type straw
Co. 19	Talai virichan mutant	R. 12	135	July-August	Coimbatore, North Arcot and South Arcot	
			2. Koilpati station			
K. 1	Irungu cholam	R. 12	135	September	Madurai, Tirunelveli and Tirunelveli	for fodder
K. 2	Vellai cholam	I. 15	120	April	,,	for grain
			3. Anakapalli station			
Akp. 1	Pacha jonna	R. 12	110	May	Visakhapatnam and Srikakulam	
Akp. 2	Thella jonna	R. 12	120	,,	,,	
Akp. 3	Dandu jonna	R. 12	110	,,	,,	Fodder strain also

				4. Guntur station		
G. 1	Mudda jonna	R. 12	120	September-October	Guntur, Krishna and Kurnool	Fodder strain also
G. 2	,,	R. 12	120	,,	,,	
G. 3	Budda gidda jonna	I. 15	90	June–July	,,	
G. 4	Yerra jonna	I. 15	85	,,	,,	
				5. Hagari station		
H. 1	Thella jonna	R. 12	135	September-October	Anantapur and Bellary	
M. 47-3	Maldandi jowar	R. 12	120	,,	,,	
				6. Nandyal station		
N. 1	Cheruku pacha jonna	R. 12	120	June	Kurnool and Cuddapah	
N. 2	Gundu pacha jonna	R. 12	120	,,	Kurnool	
N. 3	Pacha jonna	R. 12	110	,,	Cuddapah	
N. 4	Oola pacha jonna	R. 12	120	,,	,,	

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
N. 5	Pacha jonna	R. 12	110	June	Cuddapah	
N. 6	,,	R. 12	115	,,	Kurnool	
N. 7	,,	R. 12	115	,,	,,	
N. 8	,,	R. 12	115	,,	Cuddapah	
N. 9	,,	R. 12	115	,,	,,	
N. 10	Mungari oola pacha jonna	R. 12	110	,,	Kurnool	For poor soils
N. 11	Mungari cheru-ku pacha jonna	R. 12	110	,,	,,	,,
N. 12	Mungari oola pacha jonna	R. 12	110	,,	,;	,,

III. CUMBU (*Pennisetum Typhoides*)

1. Coimbatore station

Co. 1	African whip cumbu	R. 12	90	June-July	Guntur, South Arcot and Ramanathapuram
		I. 15		March	Salem, Coimbatore and Tiruchirapalli
Co. 2	Bajri-Bombay	R. 12	90	July	Madurai and Coimbatore
Co. 3	Kotapuli cumbu	I. 15	85	April	South Arcot, Tiruchirapalli, Salem, Madurai, Coimbatore and Ramanathapuram
Co. 4	Bajri-Bombay	I. 15	85	,,	Coimbatore
X. 1	Hybrid cumbu	R. 12	90	September	Salem, Coimbatore and Ramanathapuram
		I. 15		March	Salem, Madurai and Tiruchirapalli
X. 2	,,	I. 15	90	,,	Salem, Madurai and Tiruchirapalli
		R. 12		September	Salem, Coimbatore and Ramanathapuram

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	6	6	7
			2. Koilpati station			
K. 1	Kattu cumbu	R. 12 I. 15	90	October February	Madurai, Ramanathapuram and Tirunelveli	
K. 2	Panjab cumbu	I. 15	90	,,	,,	
			3. Anakapalli station			
Akp. 1	Rudrakshaganti	R. 12	90	May	Visakhapatnam and Srikakulam	
Akp. 2	Pedha ganti	R. 12	95	,,	,,	
Akp. 3	Poona ganti	R. 12	95	,,	,,	
			IV. RAGI (*Eleusine Coracana*)			
			1. Coimbatore station			
Co. 1	Gidda aryam	R. 12	120	August	North Arcot, Salem, Madurai Coimbatore and Trichirapalli	

		I. 15		May	Guntur, Nellore and Chittoor
Co. 2	Muthu ragi	I. 15	110	,,	Chingleput, North Arcot, Coimbatore and South Tamil Nad
Co. 3	Co. 1 Mutant	I. 15	110	,,	Chittoor, North Arcot, South Arcot, Chingleput, Salem and Coimbatore
Co. 4	Palladam ragi	R. 12	140	July	Tirunelveli and Ramanathapuram
		I. 15		October	,,
Co. 5	Karum churuttai ragi	R. 12 I. 15	125	August October	South Arcot, Tiruchirapalli and Coimbatore
Co. 6	Vellai ragi	I. 15	120	July	All districts
Co. 7	Extracted type	I. 15	100	,,	,,
			2. Koilpati station		
K. 1	Local ragi	I. 15	110	July	Tirunelveli and Ramanathapuram
			3. Palur station		
Plr. 1	Perum ragi	I. 15	110	April	South Arcot

Name of strain 1	Parentage 2	Percentage increased yield of strain over parent 3	Duration of strain in days (Seed to seed) 4	Time of sowing 5	Suitable regions 6	Remarks 7
			4. Anakapalli station			
Akp. 1	Burada chodi	I. 15	90	May	South Arcot, Srikakulam and Visakhapatnam	
Akp. 2	,,	I. 15	85	,,	Chingleput and Visakhapatnam	
Akp. 3	Pyru chodi	I. 15	100	December	Srikakulam	
Akp. 4	,,	I. 15	95	,,	,,	
Akp. 5	,,	I. 15	90	,,	,,	
Akp. 6	Mottu nalla chodi	R. 12 I. 15	100	{ August { June	South Arcot, Srikakulam and Visakhapatnam	
Akp. 7	Mottu thella chodi	I. 15	100	June	,,	

				5. Hagari station	
H. 1	Co. 1 mutant	I. 15	130	June	Ceded districts
				V. TENAI (*Setaria Italica*)	
				1. Coimbatore station	
Co. 1	Mosu tenai	R. 12 I. 15	100	September March	South Arcot, Salem and Coimbatore
Co. 2	Sadai tenai	I. 15	90	March	Coimbatore, Salem, Madurai and parts of Cuddapah.
Co. 3	Perum tenai	R. 12	100	September	Coimbatore, Salem and Madurai
				2. Guntur station	
G. 1	Punasa korra	R. 12	90	June	Guntur
				3. Hagari station	
H. 1	Local korra	R. 12	110	July	Bellary, Anantapur and Cuddapah
H. 2	,,	R. 12	100	,,	,,
				4. Nandyal station	
N. 1	Chena korra	R. 12	90	June	Kurnool and Cuddapah

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
			VI. VARAGU (*Paspalum Scrobiculatum*)			
			1. Coimbatore station			
Co. 1	Varagu	R. 12	150	July	Coimbatore, Tiruchirapalli, Tanjore and Tirunelveli	
			2. Palur station			
Plr. 1	Vellai varagu	R. 12	130	July	South Arcot, Tanjore and Tiruchirapalli	
			VII. PULSES			
SA. 1	Tiruppathur redgram		165	June-July	Coimbatore, Salem, North Arcot, South Arcot, Tiruchirapalli and Tanjore	
Co. 1	Coimbatore greengram		135	September	Coimbatore, Salem, North Arcot & Tiruchirapalli	

Co. 1	Coimbatore bengalgram		105	November	Coimbatore, Kurnool, Bellary, Anantapur and Cuddaph	
Vzm. 1	Vizianagaram blackgram		90	August-September	Srikakulam, Visakhapatam, East Godavari and West Godavari	
Vzm. 1	Vizianagaram horsegram		135	,,	Srikakulam and Visakhapatnam	

VIII. GROUNDNUT

Tindivanum station

Tmv. 1	Saloum of West Africa	30	135	July	Suitable for all places, particularly for Tiruchirapalli, Tanjore, Ramanathapuram, Madurai, Tirunelveli and Cuddapah	Spreading variety, drought resistant, and resistant to Leaf curl, better than others.
Tmv. 2	Spanish type		105	June and September	Guntur, Krishna, Ramanathapuram, Tirunelveli and Tanjore	Shortest duration bunch type
Tmv. 3	Bassi of West Africa	2	135	July	Salem, South Arcot, Coimbatore, Chittoor, Anantapur and Bellary	Spreading type, with a high shelling outturn
Tmv. 4	Spanish type	32	135	March	South Arcot	Spreading type, grown under irrigation

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
Tmv. 5	Gudiatham bunch x a Tanganiyaka semi spreading variety	25	110	March and July	South Arcot	Bunch type, can be grown under irrigated and rain fed conditions; does not germinate in the field at the time of harvest
			IX. GINGELLY			
			Tindivanam station			
Tmv. 1	Palni variety	33	85	1. March and 2. December	South Arcot, North Arcot, Tanjore, Tirunelveli, Salem and Coimbatore	1. Irrigated crop and 2. dry crop
Tmv. 2	Sattur x a Nagar variety	10	80	December	South Arcot, North Arcot, Tanjore and Chingleput	Dry crop
Tmv. 3	Local x a Travancore wild type	16	80	1. March and 2. December	South Arcot	1. Irrigated crop & 2.dry crop; fairly resistant to wilt

				X. CASTOR		
				Tindivanam station		
Tmv. 1	A natural cross	17	195	June-July	Bellary, Anantapur, Kurnool and Guntur	
Tmv. 2	Local South Arcot variety	21	210	,,	South Arcot, North Arcot, Tanjore and Nellore	Dry crop, but can be grown mixed with irrigated crops
Tmv. 3	Local Anamalai variety	27	10 to 15 years	,,	All places in the plains, which have heavy rains or facilities for irrigation, or in high altitudes	A perennial variety
				XI. COTTON		
Co-2. Cambodia	Bulk	10	210	September to April, (Winter)	Coimbatore, Salm, Tiruchirappalli, Madurai, Ramanathapuram, Tirunelveli & Malabar	Hardy variety grown under dry and irrigated conditions, being replaced now by M.C.U. 1, which is earlier and better in quality; spinning capacity 35's.

Name of strain	Parentage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
Madras Cam bodia Uganda.1 (M.C.U.1)	A. 12 × Co. 2	30% in summer and 10% in winter, over Co. 2	195	September to April, (winter), February to September and December to August in summer	Coimbatore, Salem, Tiruchirappalli. Madurai, Ramanathapuram, Tirunelveli, Malabar, South Arcot, North Arcot and Chingleput	Suitable for both summer and winter; staple 1″ to 1 1/16″, spinning 44's. This is being replaced now by M.C.U. 2 in summer
Madras Cambodia Uganda.2 (M.C.U.2)	Multiple hybrid	25% over M.C.U. 1	180	February to September and December	Madurai, Ramanathapuram, Tirunelveli South Arcot and Chingleput.	Staple 1″ to 1 1/8″s spinning 52's. Early and quality cotton and the best in the Indian Union
Karunganni (K. 2)	Hybrid	10% over K. 1	240	October to May	Ramanathapuram, Madurai and Tirunelveli	Suitable for Uppam Karunganni and mixed zones in Tinnies' area, spinning 29's

Karun-ganni K. 5	Hybrid	10% over K. 1	240	September to April	Palni and Dindugal of Madurai, Coimbatore and Tiruchirappalli	Drought resistant; spinning 29's
Westerns W. 1	Westerns	Nil	210	September to April	Kurnool, Bellary, Anantapur & Cuddapah	Less waste in manufacture, early, drought resistant, spinning 30's
Northerns N. 14	Northerns	,,	240	August-September to April	Kurnool	Fine, strong, spins up to 40's
Cocona-das	Hybrid		240	July to February, August to March, September to April	Guntur, Krishna Godavari and Nellore	Coloured cotton, spins up to 30's
Laxmi	Hybrid	New introduction (Bombay)	210	September to April	Rain fed and irrigated lands in Kurnool, Bellary and Cuddapah	Suitable for the black soil areas of the Ceded districts.
H. 420	Hybrid	New introduction (Madya Pradeah)	180	June to December	Bellary, Kurnool, Cuddapah, ·Nellore, Guntur and Anantapur.	Suitable for *Mungari* season and for mixed cropping with ground nut.

Name of strain	Parontage	Percentage increased yield of strain over parent	Duration of strain in days (Seed to seed)	Time of sowing	Suitable regions	Remarks
1	2	3	4	5	6	7
Punjab P. 216 F.	Hybrid	New introduction (Punjab)	165	January to July	Tanjore, South Arcot and North Arcot	An early cotton suitable for cultivation in rice fallows, under irrigation. Spins up to 36's
Sea Island	Monteserrat variety	New introduction (West Indies)	195	July to December	Malabar and South Kanara	Longest stapled for cultivation as a rain fed crop in the *kumri* lands of Malabar. Spins up to 100's

APPENDIX II

Important characteristics of improved strains of sugarcane, which are under general cultivation in Madras and Andhra States

Name of strain	Parentage	Normal tonnage of canes per acre	Season and duration	Remarks
1	2	3	4	5
B. 208	Unknown	25—30	Main season; harvested in 10 to 12 months	Called '*Bangaru-theega*' in Andhra Desa and grown mainly for chewing. The cane is soft and rich in sugars and is often mixed with poor canes during the early harvests to obtain a proper set of jaggery.
Co. 349	POJ 2725 × Co. 243	30—35	Main season: harvested in 9 to 10 months	A mid-season variety, responding well to manuring and susceptible to smut and borer damage. The cane is of rather poor quality.
Co. 419	POJ 2878 × Co. 290	35—40	Suitable for all seasons; gets ready for harvest in 9 to 10 months	Early maturing variety, which can be kept on in the field for a long time. It combines heavy yield and quality, and has yielded over 100 tons per acre in State crop yield competitions. Responds well to heavy manuring and resists drought and stagnation of water fairly well. It is susceptible to smut and breaks on lodging, being brittle. Jaggery is of medium quality. It is the major variety under cultivation in Madras and Andhra States.

Name of strain	Parentage	Normal tonnage of canes per acre	Season and duration	Remarks
1	2	3	4	5
Co. 421	POJ 2878 × Co. 285	25—30	Main season; harvested in 10–11 months	A mid-season cane, combining good yield, juice quality and drought resistance. It is a hard cane, not bitten by jackals. It forms pith in late seasons.
Co. 449	POJ 2878 × Co. 331	30—35	Main and second seasons; harvested in 10 months	A mid-season variety, with a hard rind, which does not break even on lodging and resists drought fairly well and also smut. Ratoons well, flowers sparsely and forms pith in late season. Jaggery is of good quality.
Co. 527	Co. 349 × Co. 312	30—33	Second season; harvested in 9 to 10 months	An early season variety with a hard rind and resistant to drought and smut. Ratoons well and flowers profusely. Jaggery is of medium quality. It is a popular cane in sugar factories.
Fiji B	Unknown	25—30	Main season; harvested in 10–12 months	It is grown as a chewing cane round Madras City and the smaller towns in the southern districts. The cane is rich in sugar and requires careful cultivation. It is susceptible to red rot and does not stand drought.

J. 247	Z. W. Cheribon × Fiji	25—30	Main season; harvested in 10-12 months	The variety was introduced from Java early in this century. It is rich in sugar, hard and resistant to jackal damage, but requires careful cultivation and is susceptible to red-rot and drought.
POJ 2878	POJ 2364 × Ek. 28	35—40	Main season; can be kept in the field up to 14 months	It is grown as a late season cane in the Nellikuppam sugar factory area and does not deteriorate rapidly when kept on the field after ripening.
Red Mauritius & purple Mauritius	Not known	25—30	Main season; harvested in 10-12 months	These are varieties with good juice quality, rather susceptible to red-rot, requiring careful cultivation.

APPENDIX III

LIST OF RICE STRAINS FOUND SUITABLE FOR THE SEVERAL DISTRICTS IN SOUTH INDIA

Visakhapatnam and Srikakulam.

1. *Kar (June to October)*: AKP. 1

2. *Sarva (June to December)*: AKP. 2, 3, 4, 5, 8, 9, 10, 12 and 13; BAM. 1, 3, 6, 7 and 9; MTU. 1 and G.E.B. 24.

3. *Dalwa (January to April)*: SLO. 16.

East Godavari.

1. *Kar (June to October)*; MTU. 3, 17, 18 and 20.

2. *Sarva (June to December)*: G.E.B. 24, MTU. 1, 5, 10, 14, 16 and 21; SLO. 1, 4, 5, 11, 13, 14, 15, 17 and 18.

3. *Dalwa (January to April)*: SLO. 12 and 16.

West Godavari.

1. *Kar (June to October)*: MTU 3, 17, 18 and 20.

2. *Sarva (June to December)*: MTU. 1, 5, 10, 11, 14, 16 and 21.

3. *Dalwa (January to April)*: MTU. 9 and 15.

Krishna.

1. *Kar (June to October)*: MTU. 3, 17 and 18.

2. *Sarva (June to December)*: G.E.B. 24; MTU. 1, 6, 7, 8, 11, 12, 13, 16, 19 and 22; and S.R. 26-B.

3. *Dalwa (January to April)*: MTU. 9 and 15.

Guntur.

1. *Kar (June to October):* MTU. 4, 17 and 18.

2. *Sarva (June to December):* G.E.B. 24; S.R. 26-B; MTU. 7, 8, 12, 13, 19 and 22.

Kurnool.

1. *Kar (June to October):* ADT. 3.

2. *Sarva (June to December):* G.E.B. 24 and Co. 1

Nellore.

1. *Sarva (July to January):* G.E.B. 24; Co. 15 and 19; ADT. 22; MTU. 12; BCP. 1, 2, 3, 4 and 5.

2. *Dalwa (January to April):* ADT. 3; MTU. 9. and 15.

Chittoor.

1. *Sornavari (June to December):* Co. 13 and 28; TKM. 1, 5 and 6 Early.

2. *Samba (July to February) as single crop:* G.E.B. 24; Co. 2, 15 and 19; ADT. 22; TKM. 1; BCP. 1 and 2.

3. *Late Samba (November to March) and Thaladi* Co. 2 and 5.

4. *Navarai (January to May):* Co. 13, 18 and 20; ADT. 3, 9 and 18; TKM. 4, 5 and 6.

Chingleput and northern taluks of South Arcot.

1. *Sornavari (June to October):* Co. 13; ADT. 14; TKM. 3, 5 and 6.

2. *Early samba (June to December);* G.E.B. 24; TKM. 1 and 2; BAM. 3.

3. *Late samba (November to March);* Co. 2, 19, 25 and 26; ASD. 5.

4. *Navarai (January to May):* ADT. 14 and 18. Co. 13 and 18; TKM. 5 and 6.

North Arcot.

1. *Kar (June to October):* Co. 13; ADT. 14; TKM 5 and 6.

2. *Early samba (June to December):* ADT. 22 and TKM. 1, and 2; BAM. 3.

3. *Late samba as single crop (July to February):* Co. 5, 19, 25 and 26.

4. *Late samba as thaladi (November to March):* Co. 2, 5, 19, 25 and 26; and ASD. 5.

5. *Navarai (January to May):* Co. 18; ADT. 14 and 18; TKM. 5 and 6.

Salem.

1. *Kar (June to October):* Co. 13 and 21 ; ADT. 3.

2. *Early samba (June to December):* G.E.B. 24; Co. 1 and 27; T. 672 (Patnai type).

3. *Late samba (July to February):* Co. 2, 3, 14, 19 25 and 26.

4. *Navarai (January to May):* Co. 10, 13, 21 and 22.

Coimbatore.

1. *Kar (June to October):* Co. 10, 13 and 23.

2. *Early samba (June to December):* G.E.B. 24; Co. 1; T. 672.

3. *Late Samba (July to February):* Co. 2, 3, 4, 7, 11, 15, 19, 25 and 26.

4. *Navarai (January to May):* Co. 10, 13 18 and 22.

Tanjore and southern taluks of South Arcot.

1. *Kuruvai (May to September):* ADT. 3, 4, 9, 16 20 and 23.

2. *Samba and thaladi (July to January):* ADT. 1, 2, 8, 21 and 25; Co. 15, 16, 19, 25 and 26; MTU. 16; PTB. 16.

3. *Navarai (January to April),* in Rajan channel ayacut : ADT. 23.

4. *Udu cultivation (June to January):* ADT. 6 and 7.

Tiruchirapalli.

1. *Kuruvai (May to September):* ADT. 3, 16, 19 and 20.

2. *Samba and thaladi (July to January):* ADT. 24 and 25; G.E.B. 24; Co. 2, 3, 7, 15, 16, 19, 25, and 26; PTB. 16.

3. *Navarai (February to June):* ADT. 9 and 12; Co. 13 and 20; MTU. 9 and 15.

Madurai.

1. *Kar (June to September):* Co. 13.

2. *Samba and thaladi (July to January):* G.E.B. 24; Co, 15, 16, 25 and 26.

3. *Thaladi (October to March:)* Co. 2 and 25; G.E.B. 24.

4. *Manavari (January to May):* Co. 13.

Ramanathapuram.

1. *Kar (June to September):* ASD. 2, 3, 8 and 9.

2. *Samba (July to January):* G.E.B. 24; Co. 16: ASD. 4 and 5.

3. *Thaladi (October to March)*: ASD. 5.

4. *Manavari (January to May)*: ASD. 1 and 2.

Tirunelveli.

1. *Kar (June to September)*: Co. 9; ASD. 1, 2, 3 7, 8 and 9.

2. *Samba (July to January)*: Co. 8, 12 and 16; ASD. 4 and 5.

3. *Pishanam (October to March)*: Co. 2, 19, 25 and 26; ASD. 5 and 10.

4. *Manavari (April to June)*: Co. 9 and 22.

Malabar.

1. *First crop (April to September)*: PTB. 1, 2, 5 7, 9, 10, 22, 23, 24, 25, 26, 28, 29, 30, 31 and 32; WND. 1 and 2.

2. *Second crop (September to January*, PTB. 4, 12, 15, 18, 20 and 27; G.E.B. 24; Co. 3, 5, 8, 12 and 19; ADT. 8, and WND. 1 and 2.

3. *Third crop (January to May)*: PTB. 10.

South Kanara.

1. *First crop (April to September)*: PTB. 9, 10, 11, 13, 14 and 17; MGL. 1 and 2.

2. *Second crop (September to January:)* PTB. 15, 16, and 19; G.E.B. 24; and Co. 2, 3 and 14.

3. *Third crop (January to May)*: PTB. 10.

Note :—Though the above strains are suitable for the respective tracts in a general way, some of the earlier strains have been superseded by later strains of better performance and have thus become obsolete.

Glossary of vernacular names of plants used in the text

Vernacular name	Botanical name	Tamil name	Telugu name	Kannada name	Hindi name
Chengalli gaddi	*Iseilema laxum* Hack.		Chengalli gaddi		
Cholam - syn - jonna	*Sorghum vulgare* Pers.	Cholam	Jonna	Jolla	Jowar
Cumbu	*Pennisetum typhoides* Stapf & Hubbard.	Cumbu	Sajja, ganti	Sajje	Bajra
Gogu	*Hibiscus cannabinus* Linn.	Pulichai	Gogu	Pundi	Patwa
Hariali	*Cynodon dactylon* Pers.	Hariali	Garakkagaddi	Garikehullu	Dhub
Illupai	*Bassia latifolia* Roxb.	Illupai	Ippa	Ippi	
Kolakattai	*Cenchrus ciliaris* Linn.	Kolakattai-pullu			Anjan
Korra - syn - tenai	*Setaria italica* Beauv.	Tenai	Korra	Navanne	Kangoone
Kudiraivalli	*Echinochloa frumentacea* Link.	Kudiraivalli	Uddalu		Sanwak
Panivaragu	*Panicum miliaceum* Linn.	Panivaragu	Varigalu	Baragu	Barri
Pathi	*Gossypium* sp.	Paruthi	Pathi	Hathi	Rui
Pillipesara	*Phaselous trilobus* Ait.	Pillipayaru	Pillipesara	Kohasaru	Mugani
Pinnai	*Calophyllum inophyllum* Linn.	Pinnai		Vuma	Sultana champa
Pungam	*Pongamia glabra* Vent.	Pungam	Kanuga	Honge	Kurung
Ragi	*Eleusine coracana* Gaertn.	Keppai	Ragulu	Ragi	Ragi
Samai	*Panicum miliare* Lam.	Samai	Samulu	Save	Shavan
Varagu	*Paspalum scrobiculatum* Linn.	Varagu	Arikkalu	Harika	Kodra

Glossary of vernacular terms used in the text.

1.	Akkadi	Funnel shaped seed tube tied to drill tynes, used for depositing mixed crop seeds in furrows opened by drills.
2.	Beedi	Tobacco bits wrapped in Ficus leaf, used for smoking like cigarettes.
3.	Bhodonam	North-east wind.
4.	Bhusa	Leguminous crop refuse.
5.	Borah	A big sized gunny bag.
6.	Chekku	A rotating contrivance used for extracting oil in the villages.
7.	Dhall	Split pulse
8.	Gorru	Local seed drill.
9.	Guddaly	A pick axe like tool, used for digging the soil in the Nilgiris.
10.	Guntaka	Blade harrow.
11.	Hingari	Late season.
12.	Hookah.	Smoking device, where the tobacco smoke is drawn through water.
13.	Kalappai	Plough.
14.	Kapas	Seed cotton.

15.	Kumri	Shifting cultivation in S. Kanara.
16.	Lankas	Small islands in river courses.
17.	Mammotie, or Manvetti	Spade
18.	Modan	Dry cultivation in Malabar.
19.	Molai kedai	Herds of sheep penned for compacting the soil for promoting germination.
20.	Mungari	Early season
21.	Paisal padam	Working blade harrow repeatedly for compacting soil, after sowing.
22.	Parvathi galli	North-east wind.
23.	Podu	Shifting cultivation in the Circars.
24.	Poromboke.	Waste Government land.
25.	Punam	Shifting cultivation in Malabar.
26.	Pyru galli, or Uppam kathu	South-east wind.
27.	Vayuvu mula galli	North-east wind.

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